

Appendix A
Data

Used in the Chollas Creek Metals Total Maximum Daily Loads

California Regional Water Quality Control Board, San Diego Region

PUBLIC REVIEW DRAFT
28 March 2005

Appendix A: Chollas Creek Metals (Cd) Data

Station ID	Sample Date	Total Hardness as CaCO ₃ (mg/L)		Conc. (ug/L)	actual conc. or 1/2 RL	Reporting Limit (ug/L)	CMC Freshwater CF	CCC Freshwater CF	EMC (ug/L)	Reporting Limit (ug/L)	Reference
				Dissolved Cadmium (ug/L)			Acute Dissolved Cadmium	Chronic Dissolved Cadmium	Total Cadmium		
11-87	2/12/2000	-	<	0.2	0.1	0.20	#VALUE!	#VALUE!	1.3	0.20	v
11-87	2/23/2000	-	=	0.3	0.3	0.20	#VALUE!	#VALUE!	0.7	0.20	v
11-87	3/5/2000	-	<	0.2	0.1	0.20	#VALUE!	#VALUE!	<.2 U	0.20	v
11-87	4/17/2000	-	=	0.3	0.3	0.20	#VALUE!	#VALUE!	1	0.20	v
Allways Recycling	4/12/1999	NA					#VALUE!	#VALUE!	9		s
north fork	3/15/1999	90.8	<	0.30	1.00	2.00	0.948	0.913038713	NA	-	o
north fork	3/25/1999	68	<	2.00	1.00	2.00	0.960	0.925136237	NA	-	o
north fork	4/6/1999	110	<	2.00	1.00	2.00	0.940	0.905013302	NA	-	o
SD8(1)	2/17/1994	120	=	1.40	1.40	0.20	0.936	0.90137292	1.5	0.2	k
SD8(1)	3/24/1994	71	=	1.63	1.63	0.20	0.958	0.923329999	1.7	0.2	k
SD8(1)	4/24/1994	110	=	1.13	1.13	0.20	0.940	0.905013302	1.2	0.2	k
SD8(1)	11/10/1994	150	=	0.46	0.46	0.20	0.927	0.892037041	0.5	0.2	a
SD8(1)	1/11/1995	58	=	0.77	0.77	0.20	0.967	0.931791185	0.8	0.2	a
SD8(1)	2/14/1995	100	=	1.60	1.60	0.20	0.944	0.90900089	1.7	0.2	a
SD8(1)	4/16/1995	120	=	2.34	2.34	0.20	0.936	0.90137292	2.5	0.2	a
SD8(1)	11/1/1995	91	=	0.57	0.57	0.25	0.948	0.91294666	0.6	0.25	b
SD8(1)	1/22/1996	74.5	<	0.25	0.125	0.25	0.956	0.921316786	NA	-	b
SD8(1)	1/31/1996	52.2	<	0.25	0.125	0.25	0.971	0.936199259	NA	-	b
SD8(1)	3/5/1996	78.6	=	0.44	0.44	0.25	0.954	0.919075417	NA	-	b
SD8(1)	12/9/1996	57.4	=	0.5	0.5	0.50	0.967	0.932226246	0.6	0.5	i
SD8(1)	1/16/1997	61.5	=	1.2	1.2	0.50	0.964	0.929339723	0.7	0.5	i
SD8(1)	11/10/1997	116	=	0.28	0.28	0.25	0.938	0.902791294	0.3	0.25	c
SD8(1)	12/6/1997	39.0	<	3.93	2.00	4.00	0.983	0.948395908	<4.0	4	c
SD8(1)	3/14/1998	96.4	<	3.78	2.00	4.00	0.946	0.910534838	<4.0	4	c
SD8(1)	11/8/1998	77	=	1.91	1.91	0.25	0.955	0.919935869	2	0.25	d
SD8(1)	1/25/1999	42.5	<	0.24	0.13	0.25	0.980	0.944800248	<0.25	0.25	d
SD8(1)	3/15/1999	90.8	<	0.24	0.13	0.25	0.948	0.913038713	<0.25	0.25	d
SD8(1)	3/15/1999	85	<	0.24	0.13	0.25	0.951	0.915800357	<0.25	0.25	d
SD8(1)	2/12/2000	40.9	<	0.25	0.13	0.25	0.981	0.94640574	<.25	0.25	e
SD8(1)	2/20/2000	35.1	<	0.25	0.00		0.988	0.952803981	2		h
SD8(1)	3/5/2000	45.5	<	0.25	0.13	0.25	0.977	0.941946552	<0.25	0.25	e
SD8(1)	10/27/2000	85	<	1	0.13	0.25	0.951	0.915800357	<1	0.25	f
SD8(1)	1/8/2001	78	<	1	0.13	0.25	0.954	0.919396016	<1	0.25	f
SD8(1)	2/13/2001	59	<	1	0.13	0.25	0.966	0.931075988	<1	0.25	f
SD8(1)	11/29/2001	68	<	1	0.50	1.00	0.960	0.925136237	1	1	j
SD8(1)	2/17/2002	111	<	1	0.50	1.00	0.940	0.904634675	1	1	j
SD8(1)	3/8/2002	148	<	1	0.50	1.00	0.928	0.892598633	1	1	j
SD8(1)	11/8/2002	69.1	<	1	0.50		0.959	0.924464861	<1		w
SD8(1)	2/11/2003	78	<	1	0.50		0.954	0.919396016	<1		w
SD8(1)	2/25/2003	44	<	1	0.50		0.978	0.943349074	<1		w
SD8(2)	2/12/2000	58	<	2	1.00	2.00	0.967	0.931791185	<2	2	h
SD8(2)	2/21/2000	47	<	2	1.00	2.00	0.976	0.940589525	<2	2	h
SD8(3)	2/12/2000	54	<	2	1.00	2.00	0.970	0.934780885	<2	2	h
SD8(3)	2/21/2000	36	<	2	1.00	2.00	0.987	0.951744735	<2	2	h
SD8(4)	2/12/2000	190	<	0.2	0.10	0.20	0.917	0.882147007	1.3	0.2	h ¹
SD8(4)	2/23/2000	232	=	0.3	0.30	0.20	0.909	0.873791402	0.7	0.2	h ¹
SD8(5)	2/12/2000	100	<	2	1.00	2.00	0.944	0.90900089	<2	2	h
SD8(5)	2/21/2000	63	<	2	1.00	2.00	0.963	0.928331529	<2	2	h
SD8(6)	2/12/2000	120	<	2	1.00	2.00	0.936	0.90137292	<2	2	h
SD8(6)	2/21/2000	100	<	2	1.00	2.00	0.944	0.90900089	<2	2	h
unknown	6/4/1991	484	<	1.0	0.50		0.878	0.843025932	<1		l
unknown	3/12/1992	472	<	1.0	0.50		0.879	0.844076313	<1		m

Appendix A: Chollas Creek Metals (Cd) Data

Station ID	Sample Date	Total Hardness as CaCO ₃ (mg/L)	Conc. actual conc. Reporting Limit (ug/L)					CMC Freshwater CF	CCC Freshwater CF	EMC (ug/L)	Reporting Limit (ug/L)	Reference
			Dissolved Cadmium (ug/L)					Acute Dissolved Cadmium	Chronic Dissolved Cadmium	Total Cadmium		
unknown	3/19/1992	1050	<	1.0	0.50		0.846	0.810624052	<1		n	
unknown	3/19/1992	1040	<	1.0	0.50		0.846	0.811024418	<1		n	
unknown	3/19/1992	1050	<	1.0	0.50		0.846	0.810624052	<1		n	
Mean =		158.35		1.11	0.69							
Median =		81.80		1.00	0.50							

¹ Reference h cites N/A for Total Hardness.

Acronyms:

CF- conversion factor

CMC - Criteria Maximum Concentration

CCC - Criteria Continuous Concentration

RL = Reporting Limit

WQO- water quality objective

EMC- event mean concentration

NA- not analyzed

unverified

dissolved [] calculated from total []

Reporting limit not known, concentration is 1/2 reported estimate

Appendix A: Chollas Creek Metals (Cu) Data

Station ID	Sample Date	Total Hardness as CaCO ₃ (mg/L)		Conc.	actual conc.	Reporting	CMC	CCC	EMC	Reporting	Reference
				(ug/L)	or 1/2 RL	Limit (ug/L)	Freshwater CF	Freshwater CF	(ug/L)	Limit (ug/L)	
				Dissolved Copper			Acute Dissolved Copper	Chronic Dissolved Copper	Total Copper		
11-87	2/12/2000	-	=	5.3	5.3	1	0.960	0.960	33	1	v
11-87	2/23/2000	-	=	9.6	9.6	1	0.960	0.960	19	1	v
11-87	3/5/2000	-	=	5.1	5.1	1	0.960	0.960	12	1	v
11-87	4/17/2000	-	=	11	11	1	0.960	0.960	13	1	v
Able Auto Wrecking	3/15/1999	NA					0.960	0.960	81		r
Allways Recycling	4/12/1999	NA					0.960	0.960	72		s
CREEK	2/12/2000	-	=	51.2	51.2	-	0.96	0.960	-	-	u
CREEK	3/5/2000	-	=	63	63	-	0.96	0.960	-	-	u
DPR(1)	1/8/2001	210	=	13	13	1	0.960	0.960	32	2	g
DPR(1)	2/13/2001	48	=	8	8	1	0.960	0.960	17	2	g
DPR(1)	11/12/2001	370	=	6	6		0.96	0.960	170		g
DPR(2)	2/12/2000	NA	=	5.3	5.3		0.96	0.960	33		g
DPR(2)	2/21/2000	NA	=	9.6	9.6		0.960	0.960	19		g
DPR(2)	1/8/2001	150	=	13	13	1	0.960	0.960	56	2	g
DPR(2)	2/13/2001	110	=	5	5	1	0.96	0.960	41	2	g
DPR(2)	11/12/2001	100	=	11	11		0.96	0.960	32		g
DPR(3)	1/8/2001	73	=	17	17	1	0.960	0.960	36	2	g
DPR(3)	2/13/2001	35	=	34	34	1	0.960	0.960	19	2	g
DPR(3)	11/12/2001	73	=	19	19		0.96	0.960	37		g
DPR(4)	1/8/2001	160	=	8	8	1	0.96	0.960	70	2	g
DPR(4)	2/13/2001	69	=	5	5	1	0.960	0.960	38	2	g
DPR(4)	11/12/2001	72	=	10	10		0.960	0.960	42		g
Mini Trucks & Cars	1/25/1999	NA	=	172.8	172.8		0.96	0.960	180		q
NF-1	9/1/2000	230		ND	na		0.96	0.960	ND	2	t
NF-2	9/1/2000	220	=	4.8	4.8		0.960	0.960	5	2	t
NF-3	9/1/2000	280	=	3.84	3.84		0.960	0.960	4	2	t
NF-4	9/1/2000	3200	=	28.8	28.8		0.96	0.960	30	2	t
north fork	3/15/1999	90.8	=	15.0	15.0	10	0.96	0.960	NA	-	o
north fork	3/25/1999	68	=	30.0	30.0	10	0.960	0.960	NA	-	o
north fork	4/6/1999	110	=	10.0	10.0	10	0.960	0.960	NA	-	o
SD8(1)	2/17/1994	120	=	32.6	32.6	5	0.96	0.960	34	5	k
SD8(1)	3/24/1994	71	=	27.8	27.8	5	0.96	0.960	29	5	k
SD8(1)	4/24/1994	110	=	42.2	42.2	5	0.960	0.960	44	5	k
SD8(1)	11/10/1994	150	=	34.6	34.6	5	0.960	0.960	36	5	a
SD8(1)	1/11/1995	58	=	16.3	16.3	5	0.96	0.960	17	5	a
SD8(1)	2/14/1995	100	=	38.4	38.4	5	0.96	0.960	40	5	a
SD8(1)	4/16/1995	120	=	81.6	81.6	5	0.960	0.960	85	5	a
SD8(1)	11/1/1995	91	=	44.2	44.2	5	0.960	0.960	46	5	b
SD8(1)	1/22/1996	74.5	=	12	12	5	0.96	0.960	NA	-	b
SD8(1)	1/31/1996	52.2	=	8	8	5	0.96	0.960	NA	-	b
SD8(1)	3/5/1996	78.6	=	34	34	5	0.960	0.960	NA	-	b
SD8(1)	12/9/1996	57.4	=	10	10	10	0.960	0.960	20	10	i
SD8(1)	1/16/1997	61.5	=	20	20	10	0.96	0.960	10	10	i
SD8(1)	11/10/1997	116	=	16.3	16.3	5.0	0.96	0.960	17	5	c
SD8(1)	12/6/1997	39.0	=	26.9	26.9	6.0	0.960	0.960	28	6	c
SD8(1)	3/14/1998	96.4	=	26.9	26.9	6.0	0.960	0.960	28	6	c
SD8(1)	11/8/1998	77.0	=	5.8	5.8	5	0.96	0.960	6	5	d
SD8(1)	1/25/1999	42.5	<	4.8	2.5	5	0.96	0.960	5	5	d
SD8(1)	3/15/1999	90.8	=	14.4	14.4	5	0.960	0.960	15	5	d
SD8(1)	3/15/1999	85.0	=	14.4	14.4	5	0.960	0.960	15	5	d
SD8(1)	2/12/2000	40.9	<	5	2.5	5	0.96	0.960	29	5	e, g
SD8(1)	2/20/2000	35.1	<	5	2.5	5	0.96	0.960	16	5	
SD8(1)	3/5/2000	45.5	<	5	2.5	5	0.960	0.960	14	5	e

Appendix A: Chollas Creek Metals (Cu) Data

Station ID	Sample Date	Total Hardness as CaCO ₃ (mg/L)	Conc. actual conc. Reporting				CMC	CCC	EMC (ug/L)	Reporting Limit (ug/L)	Reference
			(ug/L)	or 1/2 RL	(ug/L)	Freshwater	Freshwater				
						CF	CF				
				Dissolved Copper			Acute Dissolved Copper	Chronic Dissolved Copper	Total Copper		
SD8(1)	10/27/2000	85	=	17	17	5	0.960	0.960	27	5	f
SD8(1)	1/8/2001	78	=	13	13	5	0.96	0.960	49	5	f
SD8(1)	1/8/2001	170	=	11	11	5	0.96	0.960	65	2	g
SD8(1)	2/13/2001	45	=	4	4	5	0.960	0.960	15	2	g
SD8(1)	2/13/2001	59	<	5	2.5	5	0.960	0.960	16	5	f
SD8(1)	11/12/2001	200	=	5	5	5	0.96	0.960	97		g
SD8(1)	11/29/2001	68	=	9	9	5	0.96	0.960	27	5	j
SD8(1)	2/17/2002	111	=	24	24	5	0.960	0.960	53	5	j
SD8(1)	3/8/2002	148	=	18	18	5	0.960	0.960	56	5	j
SD8(1)	11/8/2002	69.1	=	22	22		0.96	0.960	28		w
SD8(1)	2/11/2003	78	=	52	52		0.96	0.960	33		w
SD8(1)	2/25/2003	44	=	8.8	8.8		0.960	0.960	16		w
SD8(1)	2/20/00 ¹	35.1	<	5	2.5	5	0.960	0.960	16	5	e
SD8(2)	2/12/2000	58	=	37	37	5	0.96	0.960	68	10	g
SD8(2)	2/21/2000	47	=	11	11	5	0.96	0.960	23	10	g
SD8(2)	1/8/2001	68	=	12	12	5	0.960	0.960	52	2	g
SD8(2)	2/13/2001	37	=	5	5	5	0.960	0.960	16	2	g
SD8(2)	11/12/2001	58	=	18	18		0.96	0.960	49		g
SD8(3)	2/12/2000	54	<	10	2.5	5	0.96	0.960	68	10	g
SD8(3)	2/21/2000	36	<	10	2.5	5	0.960	0.960	19	10	g
SD8(3)	1/8/2001	87	=	19	19	5	0.960	0.960	65	2	g
SD8(3)	2/13/2001	40	=	5	5	5	0.96	0.960	15	2	g
SD8(3)	11/12/2001	300	=	5	5		0.96	0.960	45		g
SD8(4)	2/12/2000	190	=	5.3	5.3	5	0.960	0.960	33	1	h ²
SD8(4)	2/23/2000	232	=	9.6	9.6	5	0.960	0.960	19	1	h ²
SD8(5)	2/12/2000	100	<	10	2.5	5	0.96	0.960	43	10	g
SD8(5)	2/21/2000	63	<	10	2.5	5	0.96	0.960	27	10	g
SD8(5)	1/8/2001	200	=	13	13	5	0.960	0.960	37	2	g
SD8(5)	2/13/2001	52	=	5	5	5	0.960	0.960	33	2	g
SD8(5)	11/12/2001	310	=	4	4		0.96	0.960	180		g
SD8(6)	2/12/2000	120	<	10	2.5	5	0.96	0.960	23	10	g
SD8(6)	2/21/2000	100	<	10	2.5	5	0.960	0.960	10	10	g
SD8(6)	1/8/2001	640	=	13	13	5	0.960	0.960	32	2	g
SD8(6)	2/13/2001	91	=	3	3	5	0.96	0.960	10	2	g
SD8(6)	11/12/2001	280	=	6	6		0.96	0.960	49		g
SF-1	9/1/2000	520					0.960	0.960	5	2	t
Trolley Auto Parts	5/5/1998	NA					0.960	0.960	500	200	p
unknown	6/4/1991	484	=	3	3		0.96	0.960	5		l
unknown	3/12/1992	472	=	7	7		0.96	0.960	7		m
unknown	3/19/1992	1050	=	7	7		0.960	0.960	36		n
unknown	3/19/1992	1040	=	7	7		0.960	0.960	6		n
unknown	3/19/1992	1050	=	8	8		0.96	0.960	7		n
Mean =		198.20		17.30	16.64						
Median =		90.80		10.00	10.00						

¹ Reference g cites date as 2/21/00.

² Reference h cites N/A for Total Hardness.

Acronyms:

CF- conversion factor

WQO- water quality objective

CMC-

CCC-

EMC- event mean concentration

NA- not analyzed

unverified

data may be duplicative

dissolved [] calculated from total []

Appendix A: Chollas Creek Metals (Pb) Data

Station ID	Sampling Date	Total Hardness as CaCO ₃ (mg/L)		Conc. (ug/L)	actual conc. or 1/2 RL	Reporting Limit (ug/L)	CMC Freshwater CF	CCC Freshwater CF	EMC (ug/L)	Reporting Limit (ug/L)	Reference
				Dissolved Lead (ug/L)			Acute Dissolved Lead	Chronic Dissolved Lead	Total Lead		
Able Auto Wrecking	3/15/1999	NA		NA			#VALUE!	#VALUE!	30		r
Allways Recycling	4/12/1999	NA		NA			#VALUE!	#VALUE!	42		s
DPR(1)	1/8/2001	210	=	1	1.0	1.0	0.683	0.683	27	2	g
DPR(1)	2/13/2001	48	=	27	27.0	1.0	0.898	0.898	23	2	g
DPR(1)	11/12/2001	370	<	1	0.5		0.600	0.600	270		g
DPR(2)	2/12/2000	NS	=	3.6	3.6		#VALUE!	#VALUE!	83		g, h
DPR(2)	2/21/2000	NS	=	10.5	10.5		#VALUE!	#VALUE!	25.9		
DPR(2)	1/8/2001	150	=	1	1.0	1.0	0.732	0.732	59	2	g
DPR(2)	2/13/2001	110	=	1	1.0	1.0	0.777	0.777	61	2	g
DPR(2)	11/12/2001	100	<	1	0.5		0.791	0.791	19		g
DPR(3)	1/8/2001	73	=	2	2.0	1.0	0.837	0.837	21	2	g
DPR(3)	2/13/2001	35	=	46	46.0	1.0	0.944	0.944	18	2	g
DPR(3)	11/12/2001	73	=	2	2.0		0.837	0.837	12		g
DPR(4)	1/8/2001	160	=	1	1.0	1.0	0.723	0.723	68	2	g
DPR(4)	2/13/2001	69	=	4	4.0	1.0	0.845	0.845	53	2	g
DPR(4)	11/12/2001	72	=	2	2.0		0.839	0.839	29		g
Mini Trucks & Cars	1/25/1999	NA					#VALUE!	#VALUE!	160		q
NF-1	9/1/2000	230	<	2	1.0	2.0	0.670	0.670	ND	2.0	t
NF-2	9/1/2000	220	=	4.1	4.1	2.0	0.676	0.676	6	2.0	t
NF-3	9/1/2000	280	=	1.3	1.3	2.0	0.641	0.641	2	2.0	t
NF-4	9/1/2000	3200	<	2	1.0	2.0	0.286	0.286	ND	2.0	t
north fork	3/15/1999	90.8	=	82	82.0	10.0	0.805	0.805	NA	-	o
north fork	3/25/1999	68	=	30	30.0	10.0	0.847	0.847	NA	-	o
north fork	4/6/1999	110	<	10	5.0	10.0	0.777	0.777	NA	-	o
SD8(1)	2/17/1994	120	=	84	84.0		0.764	0.764	110	1	k
SD8(1)	3/24/1994	71	=	118	118.0		0.841	0.841	140	1	k
SD8(1)	4/24/1994	110	=	54	54.0		0.777	0.777	70	1	k
SD8(1)	11/10/1994	150	=	26	26.0		0.732	0.732	35	1	a
SD8(1)	1/11/1995	58	=	38	38.0		0.870	0.870	44	1	a
SD8(1)	2/14/1995	100	=	87	87.0		0.791	0.791	110	1	a
SD8(1)	4/16/1995	120	=	107	107.0		0.764	0.764	140	1	a
SD8(1)	11/1/1995	91	=	18	18.0		0.805	0.805	22.9	1	b
SD8(1)	1/22/1996	74.5	<	2	0.5	1.0	0.834	0.834	NA	-	b
SD8(1)	1/31/1996	52.2	<	2	0.5	1.0	0.886	0.886	NA	-	b
SD8(1)	3/5/1996	78.6	=	18	18.0	1.0	0.826	0.826	NA	-	b
SD8(1)	12/9/1996	57.4	=	15	15.0	2.0	0.872	0.872	16	2	i
SD8(1)	1/16/1997	61.5	=	7	7.0	2.0	0.862	0.862	58	2	i
SD8(1)	11/10/1997	116	=	2	2.0		0.769	0.769	3	1	c
SD8(1)	12/6/1997	39.0	=	39	39.0		0.928	0.928	<42	42	c
SD8(1)	3/14/1998	96.4	=	76	76.0		0.796	0.796	95	42	c
SD8(1)	11/8/1998	77	<	1	0.5	-	0.829	0.829	<1	1	d
SD8(1)	1/25/1999	42.5	=	6	6.0	-	0.916	0.916	7	1	d
SD8(1)	3/15/1999	90.8	=	66	66.0	-	0.805	0.805	82	1	d
SD8(1)	3/15/1999	85	=	67	67.0	-	0.815	0.815	82	1	d
SD8(1)	2/12/2000	40.9	<	1	0.5	1.0	0.921	0.921	15	1	e
SD8(1)	2/21/2000	35.1	<	1	0.5	1.0	0.944	0.944	<1	1	e, g, h
SD8(1)	3/5/2000	45.5	<	1	0.5	1.0	0.906	0.906	<1	1	e
SD8(1)	10/27/2000	85	=	3	3.0	1.0	0.815	0.815	22	1	f
SD8(1)	1/8/2001	78	=	2	2.0	1.0	0.827	0.827	55	1	f
SD8(1)	1/8/2001	170	=	3	3.0	1.0	0.714	0.714	83	2	g
SD8(1)	2/13/2001	45	<	1	0.5	1.0	0.907	0.907	22	2	g
SD8(1)	2/13/2001	59	=	14	14.0	1.0	0.868	0.868	27	1	f
SD8(1)	11/12/2001	200	<	1	0.5		0.690	0.690	94		g

Appendix A: Chollas Creek Metals (Pb) Data

Station ID	Sampling Date	Total Hardness as CaCO ₃ (mg/L)		Conc. (ug/L)	actual conc. or 1/2 RL	Reporting Limit (ug/L)	CMC Freshwater CF	CCC Freshwater CF	EMC (ug/L)	Reporting Limit (ug/L)	Reference
				Dissolved Lead (ug/L)			Acute Dissolved Lead	Chronic Dissolved Lead	Total Lead		
SD8(1)	11/29/2001	68	<	2	1.0	2.0	0.847	0.847	28	2	j
SD8(1)	2/17/2002	111	<	2	1.0	2.0	0.776	0.776	32	2	j
SD8(1)	3/8/2002	148	=	2	2.0	2.0	0.734	0.734	61	2	j
SD8(1)	11/8/2002	69.1	=	6	6.0		0.845	0.845	17		w
SD8(1)	2/11/2003	78	<	2	1.0		0.827	0.827	29		w
SD8(1)	2/25/2003	44	<	2	1.0		0.911	0.911	23		w
SD8(2)	2/12/2000	58	<	10	5.0	10.0	0.870	0.870	34	10	g, h
SD8(2)	2/21/2000	47	<	10	5.0	10.0	0.901	0.901	23	10	g, h
SD8(2)	1/8/2001	68	=	1	1.0	1.0	0.847	0.847	91	2	g
SD8(2)	2/13/2001	37	=	1	1.0	1.0	0.936	0.936	29	2	g
SD8(2)	11/12/2001	58	<	1	0.5		0.870	0.870	39		g
SD8(3)	2/12/2000	54	<	10	5.0	10.0	0.881	0.881	52	10	g, h
SD8(3)	2/21/2000	36	<	10	5.0	10.0	0.940	0.940	19	10	g, h
SD8(3)	1/8/2001	87	=	1	1.0	1.0	0.811	0.811	90	2	g
SD8(3)	2/13/2001	40	=	2	2.0	1.0	0.925	0.925	21	2	g
SD8(3)	11/12/2001	300	=	3	3.0		0.631	0.631	52		g
SD8(4)	2/12/2000	NA	=	3.6	3.6	1.0	#VALUE!	#VALUE!	83	1	h ¹
SD8(4)	2/23/2000	NA	=	10.5	10.5	1.0	#VALUE!	#VALUE!	25.9J	1	h ¹
SD8(5)	2/12/2000	100	<	10	5.0	10.0	0.791	0.791	76	10	g, h
SD8(5)	2/21/2000	63	<	10	5.0	10.0	0.858	0.858	35	10	g, h
SD8(5)	1/8/2001	200	=	1	1.0	1.0	0.690	0.690	29	2	g
SD8(5)	2/13/2001	52	=	2	2.0	1.0	0.886	0.886	59	2	g
SD8(5)	11/12/2001	310	<	1	0.5		0.626	0.626	170		g
SD8(6)	2/12/2000	120	<	10	5.0	10.0	0.764	0.764	16	10	g, h
SD8(6)	2/21/2000	100	<	10	5.0	10.0	0.791	0.791	<10	10	g, h
SD8(6)	1/8/2001	640	=	1	1.0	1.0	0.521	0.521	19	2	g
SD8(6)	2/13/2001	91	<	1	0.5	1.0	0.805	0.805	9	2	g
SD8(6)	11/12/2001	280	<	1	0.5		0.641	0.641	36		g
SF-1	9/1/2000	520					0.551	0.551	ND	2.0	t
Trolley Auto Parts	5/5/1998	NA					#VALUE!	#VALUE!	500	200	p
unknown	6/4/1991	484	<	5	2.5		0.561	0.561	5		l
unknown	3/12/1992	472	<	5	2.5		0.565	0.565	7		m
unknown	3/19/1992	1050	=	29	29.0		0.448	0.448	5		n
unknown	3/19/1992	1040	=	16	16.0		0.450	0.450	5		n
unknown	3/19/1992	1040	=	11	11.0		0.450	0.450	5		n
11-87	4/17/2000	-	=	2.9	2.9	1.0	#VALUE!	#VALUE!	7.6	1	v
11-87	2/12/2000	-	=	3.6	3.6	1.0	#VALUE!	#VALUE!	83	1	v
11-87	3/5/2000	-	=	4.3	4.3	1.0	#VALUE!	#VALUE!	14	1	v
11-87	2/23/2000	-	=	11	11.0	1.0	#VALUE!	#VALUE!	26	1	v

Mean = 199.79 15.05 14.29
Median = 88.90 3.60 3.00

¹ Reference h cites N/A for Total Hardness.

Acronyms:

CF- conversion factor

WQO- water quality objective

CMC- criteria maximum concentration

CCC- criteria continuous criteria

EMC- event mean concentration

NA- not analyzed

	unverified
	dissolved [] calculated from total []
	data may be duplicative
	Reporting limit not known, concentration is 1/2 reported estimate

Appendix A: Chollas Creek Metals (Zn) Data

Station ID	Sampling Date	Total Hardness as CaCO ₃ (mg/L)		Conc.	actual conc.	Reporting	CMC	CCC	EMC	Reporting	Reference
				(ug/L)	or 1/2 RL	Limit (ug/L)	Freshwater CF	Freshwater CF	(ug/L)	Limit (ug/L)	
				Dissolved Zinc (ug/L)			Acute Dissolved Zinc	Chronic Dissolved Zinc	Total Zinc		
11-87	2/12/2000	-	=	17	17	1			330	1	v
11-87	2/23/2000	-	=	42	42	1			81	1	v
11-87	3/5/2000	-	=	25	25	1			49	1	v
11-87	4/17/2000	-	=	31	31	1			47	1	v
Able Auto Wrecking	3/15/1999	NA							190		r
Allways Recycling	4/12/1999	NA							260		s
CREEK	2/12/2000	-	=	150.8	150.8						u
CREEK	3/5/2000	-	=	146	146						u
DPR(1)	1/8/2001	210	=	200	200	10	0.978	0.986	190	10	g
DPR(1)	2/13/2001	48	=	250	250	10	0.978	0.986	120	10	g
DPR(1)	11/12/2001	370	=	40	40		0.978	0.986	1400		g
DPR(2)	2/12/2000	NS	=	16.8	16.8		0.978	0.986	327		g
DPR(2)	2/21/2000	NS	=	42	42		0.978	0.986	81		g
DPR(2)	1/8/2001	150	=	180	180	10	0.978	0.986	360	10	g
DPR(2)	2/13/2001	110	=	66	66	10	0.978	0.986	280	10	g
DPR(2)	11/12/2001	100	=	55	55		0.978	0.986	180		g
DPR(3)	1/8/2001	73	=	220	220	10	0.978	0.986	230	10	g
DPR(3)	2/13/2001	35	=	370	370	10	0.978	0.986	110	10	g
DPR(3)	11/12/2001	73	=	100	100		0.978	0.986	200		g
DPR(4)	1/8/2001	160	=	230	230	10	0.978	0.986	660	10	g
DPR(4)	2/13/2001	69	=	46	46	10	0.978	0.986	280	10	g
DPR(4)	11/12/2001	72	=	110	110		0.978	0.986	340		g
Mini Trucks & Cars	1/25/1999	NA					0.978	0.986	690		q
NF-1	9/1/2000	230	<	10	5	10.0	0.978	0.986	ND	10	t
NF-2	9/1/2000	220	=	45	45	10.0	0.978	0.986	46	10	t
NF-3	9/1/2000	280	=	15	15	10.0	0.978	0.986	15	10	t
NF-4	9/1/2000	3200	=	20	20	10.0	0.978	0.986	20	10	t
north fork	3/15/1999	90.8	=	210	210	10.0	0.978	0.986	NA	-	o
north fork	3/25/1999	68	=	220	220	10.0	0.978	0.986	NA	-	o
north fork	4/6/1999	110	=	90	90	10.0	0.978	0.986	NA	-	o
SD8(1)	2/17/1994	120	=	254	254		0.978	0.986	260	5	k
SD8(1)	3/24/1994	71	=	235	235		0.978	0.986	240	5	k
SD8(1)	4/24/1994	110	=	313	313		0.978	0.986	320	5	k
SD8(1)	11/10/1994	150	=	176	176		0.978	0.986	180	5	a
SD8(1)	1/11/1995	58	=	147	147		0.978	0.986	150	5	a
SD8(1)	2/14/1995	100	=	352	352		0.978	0.986	360	5	a
SD8(1)	4/16/1995	120	=	548	548		0.978	0.986	560	5	a
SD8(1)	11/1/1995	91	=	181	181		0.978	0.986	185	25	b
SD8(1)	1/22/1996	74.5	=	25	25	25	0.978	0.986	NA	-	b
SD8(1)	1/31/1996	52.2	=	32	32	25	0.978	0.986	NA	-	b
SD8(1)	3/5/1996	78.6	=	141	141	25	0.978	0.986	NA	-	b
SD8(1)	12/9/1996	57.4	=	80	80	50	0.978	0.986	70	50	i
SD8(1)	1/16/1997	61.5	=	40	40	50	0.978	0.986	200	50	i
SD8(1)	11/10/1997	116	=	172	172		0.978	0.986	176	25	c
SD8(1)	12/6/1997	39.0	=	108	108		0.978	0.986	110	2	c
SD8(1)	3/14/1998	96.4	=	90	90		0.978	0.986	92	2	c
SD8(1)	11/8/1998	77	=	30	30	25.0	0.978	0.986	30	25	d
SD8(1)	1/25/1999	42.5	=	48	48	25.0	0.978	0.986	48	25	d
SD8(1)	3/15/1999	90.8	=	210	210	25.0	0.978	0.986	210	25	d
SD8(1)	3/15/1999	85	=	210	210	25.0	0.978	0.986	210	25	d
SD8(1)	2/12/2000	40.9	=	19	19	25.0	0.978	0.986	96	25	e, g, h
SD8(1)	2/20/2000	35.1	=	28	28	25.0	0.978	0.986	50	25	e
SD8(1)	3/5/2000	45.5	=	8	8	25.0	0.978	0.986	80	25	e

Appendix A: Chollas Creek Metals (Zn) Data

Station ID	Sampling Date	Total Hardness as CaCO ₃ (mg/L)		Conc.	actual conc.	Reporting	CMC	CCC	EMC	Reporting	Reference
				(ug/L)	or 1/2 RL	Limit (ug/L)	Freshwater CF	Freshwater CF	(ug/L)	Limit (ug/L)	
				Dissolved Zinc (ug/L)			Acute Dissolved Zinc	Chronic Dissolved Zinc	Total Zinc		
SD8(1)	10/27/2000	85	=	90	90	25	0.978	0.986	150	25	f
SD8(1)	1/8/2001	78	=	110	110	25	0.978	0.986	29	25	f
SD8(1)	1/8/2001	170	=	87	87	10	0.978	0.986	480	10	g
SD8(1)	2/13/2001	45	=	32	32	10	0.978	0.986	100	10	g
SD8(1)	2/13/2001	59	=	30	30	25	0.978	0.986	120	25	f
SD8(1)	11/12/2001	200	=	62	62		0.978	0.986	740		g
SD8(1)	11/29/2001	68	=	53	53	20	0.978	0.986	162	20	j
SD8(1)	2/17/2002	111	=	118	118	20	0.978	0.986	314	20	j
SD8(1)	3/8/2002	148	=	79	79	20	0.978	0.986	430	20	j
SD8(1)	11/8/2002	69.1	=	152	152		0.978	0.986	118		w
SD8(1)	2/11/2003	78	=	139	139		0.978	0.986	230		w
SD8(1)	2/25/2003	44	=	18	18		0.978	0.986	154		w
SD8(2)	2/12/2000	58	=	45	45	10	0.978	0.986	160	10	g, h
SD8(2)	2/21/2000	47	=	67	67	10	0.978	0.986	180	10	g
SD8(2)	1/8/2001	68	=	160	160	10	0.978	0.986	420	10	g
SD8(2)	2/13/2001	37	=	36	36	10	0.978	0.986	100	10	g
SD8(2)	11/12/2001	58	=	130	130		0.978	0.986	370		g
SD8(3)	2/12/2000	54	=	20	20	10	0.978	0.986	300	10	g, h
SD8(3)	2/21/2000	36	=	57	57	10	0.978	0.986	160	10	g
SD8(3)	1/8/2001	87	=	130	130	10	0.978	0.986	480	10	g
SD8(3)	2/13/2001	40	=	36	36	10	0.978	0.986	110	10	g
SD8(3)	11/12/2001	300	=	47	47		0.978	0.986	300		g
SD8(4)	2/12/2000	190	=	16.8	16.8	1	0.978	0.986	327	1	h ²
SD8(4)	2/23/2000	232	=	42	42	1	0.978	0.986	81	1	h ²
SD8(5)	2/12/2000	100	=	45	45	10	0.978	0.986	370	10	g, h
SD8(5)	2/21/2000	63	=	10	10	10	0.978	0.986	10	10	g
SD8(5)	1/8/2001	200	=	290	290	10	0.978	0.986	260	10	g
SD8(5)	2/13/2001	52	=	68	68	10	0.978	0.986	270	10	g
SD8(5)	11/12/2001	310	=	73	73		0.978	0.986	1900		g
SD8(6)	2/12/2000	120	=	20	20	10	0.978	0.986	100	10	g, h
SD8(6)	2/21/2000	100	=	30	30	10	0.978	0.986	54	10	g
SD8(6)	1/8/2001	640	=	170	170	10	0.978	0.986	160	10	g
SD8(6)	2/13/2001	91	=	33	33	10	0.978	0.986	55	10	g
SD8(6)	11/12/2001	280	=	76	76		0.978	0.986	290		g
SF-1	9/1/2000	520	=	12	12		0.978	0.986	12	10	t
Trolley Auto Parts	5/5/1998	NA					0.978	0.986	1000	50	p
unknown	6/4/1991	484	=	3	3		0.978	0.986	6		l
unknown	3/12/1992	472	=	188	188		0.978	0.986	224		m
unknown	3/19/1992	1050	=	11	11		0.978	0.986	59		n
unknown	3/19/1992	1040	=	11	11		0.978	0.986	29		n
unknown	3/19/1992	1050	=	12	12		0.978	0.986	21		n

Mean = 200.19 102.24 102.20
Median = 90.80 66.50 66.50

² Reference h cites N/A for Total Hardness.

Acronyms:

CF- conversion factor

WQO- water quality objective

CMC-

CCC-

EMC- event mean concentration

NA- not analyzed

	unverified
	dissolved [] calculated from total []
	data may be duplicative

Appendix B
Cadmium Delisting

Used in the Chollas Creek Metals Total Maximum Daily Loads

California Regional Water Quality Control Board, San Diego Region

PUBIC REVIEW DRAFT
28 March 2005

Chollas Creek – Cadmium Delisting Hydrologic Subarea 908.22

SUMMARY OF ACTIONS

Non-consideration of dissolved cadmium for Total Maximum Daily Load (TMDL) and subsequent removal from the list of Water Quality Limited Segments [Clean Water Act (CWA) section 303(d)].

TMDL PRIORITY

Non-consideration.

LIST OF WATER QUALITY LIMITED SEGMENTS

Proposed delisting.

WATERSHED CHARACTERISTICS

Chollas Creek is an urban creek that runs through portions of San Diego, La Mesa, and Lemon Grove before emptying into San Diego Bay. Chollas Creek is designated with water contact recreation (REC-1) as a potential beneficial use as well as the following existing beneficial uses: non-contact water recreation (REC-2), warm freshwater habitat (WARM), and wildlife habitat (WILD). San Diego Bay is designated with the following beneficial uses: industrial service supply (IND), navigation (NAV), REC-1, REC-2, commercial and sport fishing (COMM), preservation for biological habitats of special significance (BIOL), estuarine habitat (EST), wildlife habitat (WILD), rare, threatened, or endangered species (RARE), marine habitat (MAR), migration of aquatic organisms (MIGR), and shellfish harvesting (SHELL) (Regional Board, 1994).

EVIDENCE OF NON-IMPAIRMENT

The available data suggests that concentrations of dissolved cadmium in Chollas Creek do not exceed acute or chronic California Toxics Rule (CTR) water quality criteria. Most samples were below detection limits, though some of the detection limit concentrations exceed CTR acute and chronic criteria. Since cadmium does not appear to exceed dissolved CTR criteria, and was not found to cause toxicity in test organisms, it is not considered an agent for the impairment of designated beneficial uses. Based on this evidence, removal of the pollutant/water body combination of cadmium and Chollas Creek from the List of Water Quality Limited Segments will be recommended by the California Regional Water Quality Control Board, San Diego Region (Regional Board).

The United States Environmental Protection Agency (USEPA) has recommended a more stringent dissolved cadmium criteria (USEPA, 2001) that it hopes California will incorporate in to the CTR by 2008. These criteria are approximately ten-fold more stringent than current CTR criteria, and may be exceeded in Chollas Creek. The available cadmium data appears to support inclusion on subsequent Water Quality Limited Segments lists based on this more stringent recommended criteria. When CTR is updated to incorporate these criteria, the Regional Board will re-evaluate the potential listing of Chollas Creek for cadmium.

As shown in the Table D.1 below, with a total of 54 samples collected and analyzed between February 2000 and February 2004, no (0 percent) exceedances of the CTR for dissolved cadmium were recorded.

Table D.1. SUMMARY OF SAMPLING EVIDENCE FOR DELISTING

CADMIUM							No. of exceedances (CTR)		No. of exceedances (USEPA, 2001)	
Collection Dates	Organization	n	min	max	mean	median	CMC	CCC	CMC	CCC
Feb 94 - Feb 03	MS4 Copermittees	42	0.2 ^a	3.93 ^b	0.8 ^c	0.5 ^c	0 ^d (4)	0 ^d (4)	0 ^d (4)	3 ^d (4)
Feb 00 - Apr 00	CalTrans	4	0.2 ^a	0.3	0.2 ^c	0.2 ^c	NA ^e	NA ^e	NA ^e	NA ^e
Mar 99 - Apr 99	SCCWRP	3	< 0.3	< 2.0	< 2.0	< 2.0	NA ^f	NA ^f	NA ^f	NA ^f
Jun 91 & Mar 92	Regional Board	5	1.0 ^a	< 1.0	0.5 ^c	0.5 ^c	NA ^f	NA ^f	NA ^f	NA ^f

a. Sample below Reporting Limit.

b. Calculated from total concentration.

c. Using all samples (measured dissolved and calculated from total). Samples below detection limit entered as 1/2 detection limit for calculations.

d. Considering only measured dissolved concentrations and samples not below DL or RL. (Number in parenthesis represents available sample pool under these criteria).

e. No associated hardness values available.

f. All samples reported as "less than."

Applying the listing policy (SWRCB, 2004) to the available cadmium data confirms that cadmium should be delisted (Table D.2). In applying the policy, total metal data and metals data without associated hardness were not considered. As seen in the table, when and if the CTR is updated to include the new cadmium criteria from the USEPA, it may be necessary to re-list cadmium. At that future time, additional data should be available to evaluate the concentrations of cadmium in the creek. Until then and in accordance with the listing policy, cadmium should be removed from the current list of water quality limited segments during the next list update.

Table D.2. 303(d) Listing Summary

	CTR		USEPA, 2001	
	CMC	CCC	CMC	CCC
No. of samples appropriate for 303(d) listing consideration	47	42	41	19
No. of exceedances	0	1	3	13
List Decision	delist	delist	delist	list

EXTENT OF NON-IMPAIRMENT

Major branches of the contributing watershed were sampled as well as the main channel. The exact locations and descriptions are as follows:

- A. **Main Chollas Channel** - Station Name SD8(1). (Longitude: 117 07.2995 Latitude: 32 42.2914) North Fork, south of Imperial Avenue. This station is located in a concrete-lined

section of the creek at the end of the 3300 block of Durant Street, near the intersection of 33rd Street, in the City of San Diego.

- B. **Wabash Avenue Branch of the Main Chollas Channel** - Station Name SD8(2). (Longitude: 117 07.1140 Latitude: 32 43.0917) North Fork, located just north of the State Highway 94 and Interstate-15 Interchange.
- C. **Home Avenue Branch of Main Chollas Channel** - Station Name SD8(3). (Longitude: 117 06.6055 Latitude: 32 43.1619) Located next to the San Diego Police Department canine training field and the Police Pistol Range and is downstream from residential areas. This area tends to remain wet year-round as a result of irrigation runoff from upstream residential areas. This portion of the creek is channelized, but has a natural bottom.
- D. **South Chollas Creek at 38th Street** - Station Name SD8(4). Located in Chollas Creek at the 38th Street Bridge, just north of Beta Street and several blocks east of Interstate 5. The station is located in a channelized portion of the creek and has a natural bottom. It is approximately 4 blocks upstream of the confluence with the north fork of Chollas Creek. This station is located within a designated open space area and the wetland water quality study area for the Chollas Creek Enhancement Project.
- E. **Federal Boulevard Branch of South Chollas Creek** - Station Name SD8(5). (Longitude: 117 04.1844 Latitude: 32 43.6324) Located in Chollas Creek at the 38th Street Bridge, just north of Beta Street and several blocks east of Interstate 5. The station is located in a channelized portion of the creek and has a natural bottom. It is approximately 4 blocks upstream of the confluence with the north fork of Chollas Creek. This station is located within a designated open space area and the wetland water quality study area for the Chollas Creek Enhancement Project.
- F. **Jamacha Road Branch of South Chollas Creek** - Station Name SD8(6). (Longitude: 117 02.9650 Latitude: 32 42.6029) Located just south of Jamacha Road at the 69th Street crossing of South Chollas Creek. The station is located just downstream from Lemon Grove and upstream of designated open space. The station is along a natural portion of the creek within a residential area and is typically wet all year long.

Based on the locations and results of the samples, non-impairment of dissolved cadmium can be determined. Data from all stations indicates that the entire watershed is free from dissolved cadmium impairment.

INFORMATION SOURCES

Regional Board, 1994. *Water Quality Control Plan for the San Diego Basin (9), 1994*. California Regional Water Quality Control Board, San Diego Region.

USEPA, 2001. *2001 Update of Ambient Water Quality Criteria for Cadmium, 2001*. United States Environmental Protection Agency, EPA-822-R-01-001.

SWRCB, 2004. *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List, 2004*. State Water Resources Control Board, September 2004.

Appendix C
Land Use Loading Analyses

Used in the Chollas Creek Metals Total Maximum Daily Load

California Regional Water Quality Control Board, San Diego Region

PUBLIC REVIEW DRAFT

28 March 2005

Appendix C: Chollas Creek Sediment Metals (Cd, Cu, Pb and Zn)

Sample Date	Station ID	Cadmium			Copper			Lead			Zinc			Comments	Reference
		Result mg/kg	Method	Limit mg/kg	Result mg/kg	Method	Limit mg/kg	Result mg/kg	Method	Limit mg/kg	Result mg/kg	Method	Limit mg/kg		
23-Sep-94	PREBAY1	0.5	EPA/SW-846 6017	5 (MDL)	33.0	EPA/SW-846 6017	0.2 (MDL)	57.0	EPA/SW-846 6017	1 (MDL)	120	EPA/SW-846 6017	5 (MDL)	dry weight	City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program Report 1994-1995
23-Sep-94	PREBAY2	ND	EPA/SW-846 6017	5 (MDL)	42.0	EPA/SW-846 6017	0.2 (MDL)	50.0	EPA/SW-846 6017	1 (MDL)	140	EPA/SW-846 6017	5 (MDL)	dry weight	
23-Sep-94	PREBAY3	0.6	EPA/SW-846 6017	5 (MDL)	430.0	EPA/SW-846 6017	0.2 (MDL)	64.0	EPA/SW-846 6017	1 (MDL)	170	EPA/SW-846 6017	5 (MDL)	dry weight	
25-Sep-94	PRECREEK1	ND	EPA/SW-846 6017	0.5 (MDL)	9.6	EPA/SW-846 6017	0.5 (MDL)	10.0	EPA/SW-846 6017	0.5 (MDL)	27	EPA/SW-846 6017	0.2 (MDL)	dry weight	
09-May-95	POSTCREEK1	0.1	EPA/SW-846 6017	0.5 (MDL)	6.4	EPA/SW-846 6017	0.5 (MDL)	14.0	EPA/SW-846 6017	0.5 (MDL)	29	EPA/SW-846 6017	0.2 (MDL)	dry weight	
10-May-95	POSTBAY1	1.2	EPA/SW-846 6017	5 (MDL)	67.0	EPA/SW-846 6017	0.2 (MDL)	150.0	EPA/SW-846 6017	1 (MDL)	190	EPA/SW-846 6017	5 (MDL)	dry weight	
10-May-95	POSTBAY2	0.8	EPA/SW-846 6017	5 (MDL)	59.0	EPA/SW-846 6017	0.2 (MDL)	71.0	EPA/SW-846 6017	1 (MDL)	160	EPA/SW-846 6017	5 (MDL)	dry weight	
10-May-95	POSTBAY3	1.4	EPA/SW-846 6017	5 (MDL)	76.0	EPA/SW-846 6017	0.2 (MDL)	120.0	EPA/SW-846 6017	1 (MDL)	220	EPA/SW-846 6017	5 (MDL)	dry weight	
28-Sep-96	1A/1B	<0.080	EPA/SW-846 6010	.5 (LDL)	186.0	EPA/SW-846 6010	.5 (LDL)	54.5	EPA/SW-846 7471	.5 (LDL)	137	EPA/SW-846 6010	2 (LDL)	dry weight	City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program 1995-1996
28-Sep-96	2A/2B	<0.080	EPA/SW-846 6010	.5 (LDL)	38.6	EPA/SW-846 6010	.5 (LDL)	55.5	EPA/SW-846 7471	.5 (LDL)	118	EPA/SW-846 6010	2 (LDL)	dry weight	
28-Sep-96	3A/3B	<0.080	EPA/SW-846 6010	.5 (LDL)	37.8	EPA/SW-846 6010	.5 (LDL)	36.8	EPA/SW-846 7471	.5 (LDL)	97.2	EPA/SW-846 6010	2 (LDL)	dry weight	
28-Sep-96	Chollas	<0.080	EPA/SW-846 6010	.5 (LDL)	3.7	EPA/SW-846 6010	.5 (LDL)	23.2	EPA/SW-846 7471	.5 (LDL)	24.2	EPA/SW-846 6010	2 (LDL)	dry weight	
02-May-96	1A/1B	<0.5	EPA/SW-846 6010	.5 (LDL)	32.7	EPA/SW-846 6010	.5 (LDL)	46.3	EPA/SW-846 7471	.5 (LDL)	141	EPA/SW-846 6010	2 (LDL)	dry weight	
02-May-96	2A/2B	<0.5	EPA/SW-846 6010	.5 (LDL)	35.7	EPA/SW-846 6010	.5 (LDL)	36.7	EPA/SW-846 7471	.5 (LDL)	102	EPA/SW-846 6010	2 (LDL)	dry weight	
02-May-96	3A/3B	<0.5	EPA/SW-846 6010	.5 (LDL)	40.0	EPA/SW-846 6010	.5 (LDL)	38.2	EPA/SW-846 7471	.5 (LDL)	105	EPA/SW-846 6010	2 (LDL)	dry weight	
02-May-96	Chollas	<0.5	EPA/SW-846 6010	.5 (LDL)	3.1	EPA/SW-846 6010	.5 (LDL)	54.1	EPA/SW-846 7471	.5 (LDL)	21.6	EPA/SW-846 6010	2 (LDL)	dry weight	
19-Sep-96	1A/1B	<1.0	EPA/SW-846 6010	0.5 (RL)	47.3	EPA/SW-846 6010	0.5 (RL)	47.3	EPA/SW-846 7471	0.5 (RL)	134	EPA/SW-846 6010	2 (RL)	dry weight	City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program Report 1996-1997
19-Sep-96	2A/2B	<1.0	EPA/SW-846 6010	0.5 (RL)	54.2	EPA/SW-846 6010	0.5 (RL)	32.0	EPA/SW-846 7471	0.5 (RL)	107	EPA/SW-846 6010	2 (RL)	dry weight	
19-Sep-96	3A/3B	<1.0	EPA/SW-846 6010	0.5 (RL)	58.6	EPA/SW-846 6010	0.5 (RL)	37.3	EPA/SW-846 7471	0.5 (RL)	111	EPA/SW-846 6010	2 (RL)	dry weight	
19-Sep-96	Chollas	<0.5	EPA/SW-846 6010	0.5 (RL)	3.6	EPA/SW-846 6010	0.5 (RL)	9.0	EPA/SW-846 7471	0.5 (RL)	28.8	EPA/SW-846 6010	2 (RL)	dry weight	
01-May-97	1A/1B	0.6	EPA/SW-846 6010	0.5 (RL)	51.5	EPA/SW-846 6010	0.5 (RL)	31.6	EPA/SW-846 7471	0.5 (RL)	132	EPA/SW-846 6010	2 (RL)	dry weight	
01-May-97	2A/2B	<0.4	EPA/SW-846 6010	0.5 (RL)	55.3	EPA/SW-846 6010	0.5 (RL)	48.5	EPA/SW-846 7471	0.5 (RL)	139	EPA/SW-846 6010	2 (RL)	dry weight	
01-May-97	3A/3B	<0.4	EPA/SW-846 6010	0.5 (RL)	58.4	EPA/SW-846 6010	0.5 (RL)	45.7	EPA/SW-846 7471	0.5 (RL)	156	EPA/SW-846 6010	2 (RL)	dry weight	
01-May-97	Chollas	<0.4	EPA/SW-846 6010	0.5 (RL)	3.1	EPA/SW-846 6010	0.5 (RL)	5.3	EPA/SW-846 7471	0.5 (RL)	27.4	EPA/SW-846 6010	2 (RL)	dry weight	
29-Sep-97	1A/1B	<0.5	EPA 6010	0.25 (DL)	67.9	EPA 6010	5 (DL)	53.9	EPA 6010	1 (DL)	179	EPA 6010	25 (DL)	assume dry weight	

Appendix C: Chollas Creek Sediment Metals (Cd, Cu, Pb and Zn)

Sample Date	Station ID	Cadmium			Copper			Lead			Zinc			Comments	Reference
		Result mg/kg	Method	Limit mg/kg	Result mg/kg	Method	Limit mg/kg	Result mg/kg	Method	Limit mg/kg	Result mg/kg	Method	Limit mg/kg		
29-Sep-97	2A/2B	<0.5	EPA 6010	0.25 (DL)	60.7	EPA 6010	5 (DL)	39.2	EPA 6010	1 (DL)	144	EPA 6010	25 (DL)	assume dry weight	City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program Report 1997- 1998
29-Sep-97	3A/3B	<0.5	EPA 6010	0.25 (DL)	69.6	EPA 6010	5 (DL)	76.0	EPA 6010	1 (DL)	157	EPA 6010	25 (DL)	assume dry weight	
30-Sep-97	Chollas	<0.5	EPA 6010	0.25 (DL)	7.9	EPA 6010	5 (DL)	9.0	EPA 6010	1 (DL)	29	EPA 6010	25 (DL)	assume dry weight	
05-May-98	1A/1B	<0.5	EPA 213.1	0.05 (DL)	59.0	EPA 220.1	0.05 (DL)	110.0	EPA 239.1	0.05 (DL)	202	EPA 289.1	0.05 (DL)	assume dry weight	
05-May-98	2A/2B	<0.5	EPA 213.1	0.05 (DL)	72.0	EPA 220.1	0.05 (DL)	130.0	EPA 239.1	0.05 (DL)	190	EPA 289.1	0.05 (DL)	assume dry weight	
05-May-98	3A/3B	<0.5	EPA 213.1	0.05 (DL)	40.0	EPA 220.1	0.05 (DL)	67.0	EPA 239.1	0.05 (DL)	102	EPA 289.1	0.05 (DL)	assume dry weight	
15-May-98	Chollas	<0.5	EPA 213.1	0.05 (DL)	<0.5	EPA 220.1	0.05 (DL)	0.8	EPA 239.1	0.05 (DL)	16.2	EPA 289.1	0.05 (DL)	assume dry weight	
18-Jun-98	978-270	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	26.8	EPA 6010	5.0 (DL)	wet weight	Lab Results. 18 June 98. Sampling by R. Kolb (P of SD) Truesdail Laboratories, Inc.
18-Jun-98	978-271	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	18.5	EPA 6010	5.0 (DL)	wet weight. Duplicate	
18-Jun-98	978-272	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	30.1	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-273	ND	EPA 6010	5.0 (DL)	6.2	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	45.6	EPA 6010	5.0 (DL)	wet weight. Duplicate	
18-Jun-98	978-274	ND	EPA 6010	5.0 (DL)	9.1	EPA 6010	5.0 (DL)	29.9	EPA 6010	12.5 (DL)	35.8	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-275	ND	EPA 6010	5.0 (DL)	32.7	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	33.6	EPA 6010	5.0 (DL)	wet weight. Duplicate	
18-Jun-98	978-276	ND	EPA 6010	5.0 (DL)	35.8	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	28.6	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-278	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	25.0	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-279	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	73.5	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-280	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	55.1	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-281	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	67.2	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-282	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	53.9	EPA 6010	5.0 (DL)	wet weight. Duplicate	
18-Jun-98	978-283	ND	EPA 6010	5.0 (DL)	10.7	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	95.9	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-284	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	50.9	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	278-285	ND	EPA 6010	5.0 (DL)	25.4	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	69.9	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-286	ND	EPA 6010	5.0 (DL)	5.6	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	125.0	EPA 6010	5.0 (DL)	wet weight. Duplicate	
18-Jun-98	978-287	ND	EPA 6010	5.0 (DL)	5.6	EPA 6010	5.0 (DL)	12.5	EPA 6010	12.5 (DL)	75.1	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-288	ND	EPA 6010	5.0 (DL)	9.1	EPA 6010	5.0 (DL)	25.3	EPA 6010	12.5 (DL)	88.9	EPA 6010	5.0 (DL)	wet weight. Duplicate	
18-Jun-98	978-289	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	36.0	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-290	ND	EPA 6010	5.0 (DL)	13.5	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	44.9	EPA 6010	5.0 (DL)	wet weight. Duplicate	
18-Jun-98	978-291	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	27.9	EPA 6010	12.5 (DL)	61.8	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-292	ND	EPA 6010	5.0 (DL)	7.0	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	40.1	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-293	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	42.2	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-294	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	24.8	EPA 6010	5.0 (DL)	wet weight	
18-Jun-98	978-295	ND	EPA 6010	5.0 (DL)	6.2	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	45.0	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-296	ND	EPA 6010	5.0 (DL)	5.1	EPA 6010	5.0 (DL)	23.0	EPA 6010	12.5 (DL)	56.9	EPA 6010	5.0 (DL)	wet weight	Lab Results. 19 June 98. Sampling by R. Kolb (P of SD) Truesdail Laboratories, Inc.
19-Jun-98	978-297	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	42.6	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-298	ND	EPA 6010	5.0 (DL)	5.4	EPA 6010	5.0 (DL)	53.5	EPA 6010	12.5 (DL)	67.9	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-299	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	13.8	EPA 6010	12.5 (DL)	56.2	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-300	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	51.4	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-301	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	26.0	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-302	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	44.3	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-303	ND	EPA 6010	5.0 (DL)	5.9	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	43.2	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-304	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	32.2	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-305	ND	EPA 6010	5.0 (DL)	9.7	EPA 6010	5.0 (DL)	20.8	EPA 6010	12.5 (DL)	112.0	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-306	ND	EPA 6010	5.0 (DL)	17.9	EPA 6010	5.0 (DL)	129.0	EPA 6010	12.5 (DL)	203.0	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-307	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	44.2	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-308	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	32.1	EPA 6010	5.0 (DL)	wet weight	

Appendix C: Chollas Creek Sediment Metals (Cd, Cu, Pb and Zn)

Sample Date	Station ID	Cadmium			Copper			Lead			Zinc			Comments	Reference
		Result mg/kg	Method	Limit mg/kg	Result mg/kg	Method	Limit mg/kg	Result mg/kg	Method	Limit mg/kg	Result mg/kg	Method	Limit mg/kg		
19-Jun-98	978-309	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	18.8	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-310	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	23.0	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-311	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	44.5	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-312	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	25.8	EPA 6010	5.0 (DL)	wet weight	
19-Jun-98	978-313	ND	EPA 6010	5.0 (DL)	9.0	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	42.6	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-314	ND	EPA 6010	0.4	13.7	EPA 6010	0.4	150.0	EPA 6010	1.0	72.8	EPA 6010	0.4	wet weight. analyzed on 28 Sep 98	Lab Results. 26 June 98. Sampling by R. Kolb (P of SD) Truesdail Laboratories, Inc.
26-Jun-98	978-315	ND	EPA 6010	5.0 (DL)	8.2	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	88.8	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-316	?	EPA 6010	5.0 (DL)	?	EPA 6010	5.0 (DL)	?	EPA 6010	12.5 (DL)	?	EPA 6010	5.0 (DL)	wet weight. metals analysis requested, data report missing	
26-Jun-98	978-317	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	34.2	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-318	1.1	EPA 6010	0.4	26.3	EPA 6010	0.4	36.7	EPA 6010	1.0	182.0	EPA 6010	0.4	wet weight. analyzed on 28 Sep 98	
26-Jun-98	978-319	ND	EPA 6010	0.4	6.1	EPA 6010	0.4	9.2	EPA 6010	1.0	53.8	EPA 6010	0.4	wet weight. analyzed on 28 Sep 98	
26-Jun-98	978-320	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	25.9	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-321	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	34.2	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-322	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	17.6	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-323	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	5.8	EPA 6010	12.5 (DL)	30.9	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-324	ND	EPA 6010	0.4	20.0	EPA 6010	0.4	1.7	EPA 6010	1.0	26.2	EPA 6010	0.4	wet weight. analyzed on 28 Sep 98	
26-Jun-98	978-325	ND	EPA 6010	0.4	4.0	EPA 6010	0.4	6.7	EPA 6010	1.0	24.3	EPA 6010	0.4	wet weight. analyzed on 28 Sep 98	
26-Jun-98	978-326	0.44	EPA 6010	0.4	9.1	EPA 6010	0.4	12.3	EPA 6010	1.0	81.1	EPA 6010	0.4	wet weight. analyzed on 28 Sep 98	
26-Jun-98	978-327	?	EPA 6010	5.0 (DL)	?	EPA 6010	5.0 (DL)	?	EPA 6010	12.5 (DL)	?	EPA 6010	5.0 (DL)	wet weight. metals analysis requested, data report missing	
26-Jun-98	978-328	?	EPA 6010	5.0 (DL)	?	EPA 6010	5.0 (DL)	?	EPA 6010	12.5 (DL)	?	EPA 6010	5.0 (DL)	wet weight. metals analysis requested, data report missing	
26-Jun-98	978-329	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	26.2	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-330	ND	EPA 6010	0.4	2.2	EPA 6010	0.4	ND	EPA 6010	1.0	16.0	EPA 6010	0.4	wet weight. analyzed on 28 Sep 98	
26-Jun-98	978-331	?	EPA 6010	5.0 (DL)	?	EPA 6010	5.0 (DL)	?	EPA 6010	12.5 (DL)	?	EPA 6010	5.0 (DL)	wet weight. metals analysis requested, data report missing	
26-Jun-98	978-332	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	5.7	EPA 6010	12.5 (DL)	21.9	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-333	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	20.2	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-334	ND	EPA 6010	5.0 (DL)	23.9	EPA 6010	5.0 (DL)	52.9	EPA 6010	12.5 (DL)	72.9	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-335	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	32.3	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-336	ND	EPA 6010	5.0 (DL)	7.1	EPA 6010	5.0 (DL)	34.7	EPA 6010	12.5 (DL)	52.9	EPA 6010	5.0 (DL)	wet weight	
26-Jun-98	978-337	22.9	EPA 6010	5.0 (DL)	ND	EPA 6010	5.0 (DL)	ND	EPA 6010	12.5 (DL)	20.9	EPA 6010	5.0 (DL)	wet weight	
28-Sep-98	1A/1B	<0.5	EPA 6010A	0.5	51.7	EPA 6010A	0.5	27.0	EPA 6010	0.5	143.0	EPA 6010A	0.5	assume dry weight	City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program Report 1998- 1999
28-Sep-98	2A/2B	<0.5	EPA 6010A	0.5	83.6	EPA 6010A	0.5	34.8	EPA 6010	0.5	172.0	EPA 6010A	0.5	assume dry weight	
28-Sep-98	3A/3B	<0.5	EPA 6010A	0.5	57.9	EPA 6010A	0.5	31.8	EPA 6010	0.5	117.0	EPA 6010A	0.5	assume dry weight	
29-Sep-98	Chollas	<0.5	EPA 6010A	0.5	3.3	EPA 6010A	0.5	8.2	EPA 6010	0.5	260.0	EPA 6010A	0.5	assume dry weight	
10-May-99	1A/1B	2.5	EPA 6010A	0.5	103.0	EPA 6010A	0.5	52.0	EPA 6010	0.5	211.0	EPA 6010A	0.5	assume dry weight	
10-May-99	2A/2B	2.4	EPA 6010A	0.5	86.0	EPA 6010A	0.5	56.0	EPA 6010	0.5	205.0	EPA 6010A	0.5	assume dry weight	
10-May-99	3A/3B	1.8	EPA 6010A	0.5	84.0	EPA 6010A	0.5	46.0	EPA 6010	0.5	221.0	EPA 6010A	0.5	assume dry weight	
11-May-99	Chollas	0.5	EPA 6010A	0.5	22.0	EPA 6010A	0.5	73.0	EPA 6010	0.5	75.0	EPA 6010A	0.5	assume dry weight	

Appendix C: Chollas Creek Sediment Metals (Cd, Cu, Pb and Zn)

Sample Date	Station ID	Result mg/kg	Cadmium Method	Limit mg/kg	Result mg/kg	Copper Method	Limit mg/kg	Result mg/kg	Lead Method	Limit mg/kg	Result mg/kg	Zinc Method	Limit mg/kg	Comments	Reference
27-Sep-98	1A/1B	<0.5	EPA 6010A	0.5 (RL)	89.1	EPA 6010A	0.5 (RL)	52.4	EPA 6010	0.5 (RL)	172.0	EPA 6010A	0.5 (RL)	assume dry weight	City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program Report 1999-2000
27-Sep-98	2A/2B	<0.5	EPA 6010A	0.5 (RL)	90.4	EPA 6010A	0.5 (RL)	68.0	EPA 6010	0.5 (RL)	166.0	EPA 6010A	0.5 (RL)	assume dry weight	
27-Sep-98	3A/3B	<0.5	EPA 6010A	0.5 (RL)	99.5	EPA 6010A	0.5 (RL)	76.8	EPA 6010	0.5 (RL)	173.0	EPA 6010A	0.5 (RL)	assume dry weight	
27-Sep-98	Chollas	0.8	EPA 6010A	0.5 (RL)	4.7	EPA 6010A	0.5 (RL)	23.2	EPA 6010	0.5 (RL)	32.7	EPA 6010A	0.5 (RL)	assume dry weight	
3-May-00	1A/1B	<0.5	EPA 6010A	0.5 (RL)	77.4	EPA 6010A	0.5 (RL)	82.4	EPA 6010	0.5 (RL)	186.0	EPA 6010A	0.5 (RL)	assume dry weight	
3-May-00	2A/2B	<0.5	EPA 6010A	0.5 (RL)	168.0	EPA 6010A	0.5 (RL)	79.5	EPA 6010	0.5 (RL)	253.0	EPA 6010A	0.5 (RL)	assume dry weight	
3-May-00	3A/3B	<0.5	EPA 6010A	0.5 (RL)	108.0	EPA 6010A	0.5 (RL)	76.3	EPA 6010	0.5 (RL)	261.0	EPA 6010A	0.5 (RL)	assume dry weight	
3-May-00	Chollas	<0.5	EPA 6010A	0.5 (RL)	26.0	EPA 6010A	0.5 (RL)	32.5	EPA 6010	0.5 (RL)	108.0	EPA 6010A	0.5 (RL)	assume dry weight	
2-Oct-00	1A/1B	<0.1	EPA 3050/6020	no info	4.6	EPA 3050/6020	no info	10.3	EPA 3050/6020	no info	33.0	EPA 3050/6020	no info	dry weight; 03-Oct-00 is before first rain; no post-rain data	City of San Diego and Co-Permittee NPDES Stormwater Monitoring Program Draft Report 2000-2001
2-Oct-00	2A/2B	0.3	EPA 3050/6020	no info	76.0	EPA 3050/6020	no info	46.5	EPA 3050/6020	no info	99.0	EPA 3050/6020	no info	dry weight; 03-Oct-00 is before first rain; no post-rain data	
2-Oct-00	3A/3B	0.4	EPA 3050/6020	no info	126.0	EPA 3050/6020	no info	68.4	EPA 3050/6020	no info	172.0	EPA 3050/6020	no info	dry weight; 03-Oct-00 is before first rain; no post-rain data	
3-Oct-00	Chollas	0.5	EPA 3050/6020	no info	116.0	EPA 3050/6020	no info	65.7	EPA 3050/6020	no info	172.0	EPA 3050/6020	no info	dry weight; 03-Oct-00 is before first rain; no post-rain data	
17 and 18 Jul 01	C14	1.4	-	-	94.9	-	-	103.0	-	-	347.0	-	-		Characterization of Sediment Toxicity in Chollas and Paleta Creek Toxic Hot Spot Sediments, San Diego Bay Summary Report, SCCWRP. 23 Apr 2003.
12-Sep-01	Chollas Creek North Fork	<0.1	EPA 3050/6020	0.1 (RL)	5.5	EPA 3050/6020	0.5 (RL)	7.9	EPA 3050/6020	0.5 (RL)	37.0	EPA 3050/6021	5 (RL)	dry weight; report also contains wet weight values (see Excel Comments)	City of San Diego and Co-Permittees NPDES Storm Water Monitoring Program Addendum 2000-2001
12-Sep-01	Chollas Creek South Fork	0.8	EPA 3050/6020	0.2 (RL)	41.6	EPA 3050/6020	0.8 (RL)	68.9	EPA 3050/6020	7.9 (RL)	252.0	EPA 3050/6022	79 (RL)	dry weight; report also contains wet weight values (see Excel Comments)	
12-Sep-01	Chollas Creek South Fork (Dup)	0.8	EPA 3050/6020	0.2 (RL)	40.9	EPA 3050/6020	0.8 (RL)	67.0	EPA 3050/6020	7.9 (RL)	269.0	EPA 3050/6023	79 (RL)	dry weight; report also contains wet weight values (see Excel Comments); duplicate	
12-Sep-01	Chollas Creek Downstream	0.2	EPA 3050/6020	0.1 (RL)	8.5	EPA 3050/6020	0.5 (RL)	17.4	EPA 3050/6020	0.5 (RL)	37.0	EPA 3050/6024	5 (RL)	dry weight; report also contains wet weight values (see Excel Comments)	

Appendix C: Sediment Sampling Stations in Chollas Creek

Date of Sampling	Station ID	Location	Sampler	Comments
18-Jun-98	978-270	S. Chollas u/s of confluence	RK	
18-Jun-98	978-271	S. Chollas u/s of confluence	BC	Duplicate
18-Jun-98	978-272	N. Chollas u/s of confluence	BC	
18-Jun-98	978-273	N. Chollas u/s of confluence	BC	Duplicate
18-Jun-98	978-274	Main Chollas d/s of confluence	BC	
18-Jun-98	978-275	Main Chollas d/s of confluence	BC	Duplicate
18-Jun-98	978-276	S. Chollas u/s of National Ave	RK	
18-Jun-98	978-278	S. Chollas d/s of National Ave	BC	
18-Jun-98	978-279	S. Chollas d/s of Imperial Ave	BC	
18-Jun-98	978-280	S. Chollas d/s of Imperial Ave in ditch	RK	
18-Jun-98	978-281	S. Chollas u/s of Imperial Ave	BC	
18-Jun-98	978-282	S. Chollas u/s of Imperial Ave	RK	Duplicate
18-Jun-98	978-283	S. Chollas u/s of 47th Street	BC	
18-Jun-98	978-284	S. Chollas d/s of 47th Street	RK	
18-Jun-98	278-285	S. Chollas Encanto Branch u/s of confluence	BC	
18-Jun-98	978-286	S. Chollas Encanto Branch u/s of confluence	RK	Duplicate
18-Jun-98	978-287	S. Chollas u/s of Encanto confluence	RK	
18-Jun-98	978-288	S. Chollas u/s of Encanto confluence	RK	Duplicate
18-Jun-98	978-289	S. Chollas d/s of Encanto confluence	BC	
18-Jun-98	978-290	S. Chollas d/s of Encanto confluence	RK	Duplicate
18-Jun-98	978-291	S. Chollas w/in Radio Canyon Branch	BC	
18-Jun-98	978-292	S. Chollas u/s of Radio Cnyn Branch confluence	BC	
18-Jun-98	978-293	S. Chollas d/s of Radio Cnyn Branch confluence	RK	
18-Jun-98	978-294	S. Chollas Jamacha Branch u/s of confluence w/Encanto Branch west of 68th St	BC	
18-Jun-98	978-295	S. Chollas Jamacha Branch u/s of confluence w/Encanto Branch at 69th St	RK	
19-Jun-98	978-296	S. Chollas Main Branch at Lenox	BC	
19-Jun-98	978-297	S. Chollas Main Branch at Lenox	RK	Duplicate
19-Jun-98	978-298	S. Chollas Main Branch at Kelton	BC	
19-Jun-98	978-299	S. Chollas Main Branch 600' E of Kelton	RK	
19-Jun-98	978-300	S. Chollas Main Branch at Federal	RK	
19-Jun-98	978-301	S. Chollas Main Branch at 6700 Central	RK	
19-Jun-98	978-302	Main Chollas at Logan/Gregory	BC	
19-Jun-98	978-303	Main Chollas at National Ave-north side	RK	
19-Jun-98	978-304	Main Chollas at National Ave - south side	RK	
19-Jun-98	978-305	Main Chollas at National Ave - north side in storm drain	BC	
19-Jun-98	978-306	Main Chollas at 35th & Martin	RK	
19-Jun-98	978-307	Main Chollas in the Greenwood Cemetary Tributary	RK	
19-Jun-98	978-308	Main Chollas at Market (1 block west)	BC	
19-Jun-98	978-309	Main Chollas at Market (east)	RK	

Appendix C: Sediment Sampling Stations in Chollas Creek

Date of Sampling	Station ID	Location	Sampler	Comments
19-Jun-98	978-310	Main Wabash Branch (north of 94)	RK	
19-Jun-98	978-311	Home Ave Branch u/s of Main Chollas in storm drain	RK	
19-Jun-98	978-312	Home Ave Branch u/s of Main Chollas u/s of storm drain	BC	
19-Jun-98	978-313	Home Ave Branch u/s of Main Chollas d/s of storm drain	RK	
26-Jun-98	978-314	Main Chollas at Home Ave above pipe	DL	
26-Jun-98	978-315	Main Chollas at Home Ave below pipe	BC	
26-Jun-98	978-316	Main Chollas at Home Ave at pipe	BC	
26-Jun-98	978-317	Main Chollas at Home Ave E of Menlo d/s of pipe	BC	
26-Jun-98	978-318	Main Chollas at Home Ave E of Menlo in side ditch	BC	
26-Jun-98	978-319	Main Chollas at Home Ave E of Menlo u/s of pipe	DL	
26-Jun-98	978-320	Main Chollas at Home Ave E of Euclid	DL	
26-Jun-98	978-321	Main Chollas at Home Ave d/s of Auburn Dr	DL	
26-Jun-98	978-322	Main Chollas at Home Ave u/s of Auburn Dr	DL	
26-Jun-98	978-323	Main Chollas at Home Ave 1000' E of Auburn / Ontario	BC	
26-Jun-98	978-324	Main Chollas u/s of Federal / 805 u/s of side drainage	DL	
26-Jun-98	978-325	Main Chollas u/s of Federal / 805 in side drainage	DL	
26-Jun-98	978-326	Main Chollas u/s of Federal / 805 d/s of drainage	BC	
26-Jun-98	978-327	Main Chollas u/s of Chollas Lake drain	BC	
26-Jun-98	978-328	Main Chollas in Chollas Lake drain	DL	
26-Jun-98	978-329	Main Chollas d/s of Chollas Lake drain	DL	Samples 327-329 and 330-332 were taken from u/s to d/s according to the time entry on the COC.
26-Jun-98	978-330	Main Chollas u/s of Trailer Park Drain	BC	
26-Jun-98	978-331	Main Chollas in Trailer Park Drain	DL	
26-Jun-98	978-332	Main Chollas d/s of Trailer Park Drain	BC	
26-Jun-98	978-333	Main Chollas east of Euclid	DL	
26-Jun-98	978-334	Main Chollas east of 54th Street		
26-Jun-98	978-335	Main Chollas, deep and just u/s of S. Chollas		Samples 335 & 337 were sampled from u/s to d/s according to the time entries on
26-Jun-98	978-336	S. Chollas, deep, just u/s of Main Chollas		
26-Jun-98	978-337	Main Chollas, deep and just d/s of S. Chollas		
23-Sep-94	PREBAY1	composite from stations 1A and 1B pre-wet season		
23-Sep-94	PREBAY2	composite from stations 2A and 2B pre-wet season		
23-Sep-94	PREBAY3	composite from stations 3A and 3B pre-wet season		
25-Sep-94	PRECREEK1	approximately .25 miles upstream from SD8(1), pre-wet season		
09-May-95	POSTCREEK1	approximately .25 miles upstream from SD8(1), post-wet season		
10-May-95	POSTBAY1	composite from stations 1A and 1B post-wet season		
10-May-95	POSTBAY2	composite from stations 2A and 2B post-wet season		
10-May-95	POSTBAY3	composite from stations 3A and 3B post-wet season		
	1A (SD Bay)	lat 32 deg 41.251"/ long 117 deg 07.938"		
	1B (SD Bay)	lat 32 deg 41.238"/ long 117 deg 07.935"		
	2A (SD Bay)	lat 32 deg 41.248"/ long 117 deg 07.953"		

Appendix C: Sediment Sampling Stations in Chollas Creek

Date of Sampling	Station ID	Location	Sampler	Comments
	2B (SD Bay)	lat 32 deg 41.233" / long 117 deg 07.941"		
	3A (SD Bay)	lat 32 deg 41.241" / long 117 deg 07.955"		
	3B (SD Bay)	lat 32 deg 41.222" / long 117 deg 09.954"		
	chollas			
12-Sep-01	Chollas Crk North Fork			GPS coordinates mentioned, but not supplied
12-Sep-01	Chollas Crk South Fork			
12-Sep-01	Chollas Crk South Fork (Dup)			
12-Sep-01	Chollas Creek Downstream			

Appendix D

Wet and Dry Weather Models

Used in the Chollas Creek Metals Total Maximum Daily Load

California Regional Water Quality Control Board, San Diego Region

PUBLIC REVIEW DRAFT

28 March 2005

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1. Watershed Modeling and General Considerations

Models are developed as tools to perform experiments on watersheds that would otherwise be impractical or impossible due to cost, personnel, or time constraints (Nix, 1994). A significant advantage of watershed modeling is the ability to process and effectively present copious amounts of spatial and time-series data. Additionally, models can prove beneficial in data-limited environments; they can estimate values for unavailable or incomplete data sets by utilizing available preexisting data in the model calibration process. These functionalities allow users to determine the impacts of different parameters on the natural processes occurring in a watershed.

Watershed-scale models range from simple to complex. Simple models are used to rapidly identify critical areas in the environment and are often utilized when data limitations and financial constraints prohibit the use of more complex models. Simple models describe a limited number of hydrologic and water quality processes and are used to estimate pollutant loadings, thus acting as a screening tool. More complex models depend on deterministic algorithms that closely simulate the physical processes in the watershed. Additionally, such models are data intensive and require substantial model calibration to accurately depict the natural system.

In selecting an appropriate approach to support the Total Maximum Daily Load (TMDL) for Chollas Creek, technical and regulatory criteria were considered. Technical criteria include the physical system in question, including the constituents of interest and watershed or stream characteristics and processes (physical domain, source contributions, critical conditions, and constituents). Consideration of each topic was critical in selecting the most appropriate modeling system to address the types of sources associated with the listed waters.

Representation of the physical domain is perhaps the most important consideration in model selection. The physical domain is the focus of the modeling effort—typically, either the receiving water itself or a combination of the contributing watershed and the receiving water. Selection of the appropriate modeling domain depends on the constituents and the conditions under which the stream exhibits impairment. For streams affected additionally or solely by nonpoint sources or primarily rainfall-driven flow and pollutant contributions, a dynamic approach is recommended. Dynamic watershed models consider time-variable nonpoint source contributions from a watershed surface or subsurface. Some models consider monthly or seasonal variability, while others enable assessment of conditions immediately before, during, and after individual rainfall events. Dynamic models require a substantial amount of information regarding input parameters and data for calibration purposes.

1.1. Source Contributions of Metal Loads

The primary sources contributions of metal loads to Chollas Creek had to be considered in the model selection process. Accurately representing contributions from nonpoint sources and regulated point sources is critical in properly representing the system and ultimately evaluating potential load reduction scenarios.

Water quality monitoring data were not sufficient to fully characterize all sources of metals in the Chollas Creek watershed. However, analyses of the available data indicate that the main sources are associated with surface runoff. As a result, the models selected to develop copper, lead, and zinc TMDLs for the Chollas Creek watershed need to address the major source categories during dry and wet weather conditions.

1.2. Critical Conditions

The critical condition is the set of natural conditions, including flow rates and critical points that identifies when and where a water body exhibits the most vulnerability. In the Chollas Creek Metals TMDL project, separate critical flow conditions were identified for dry and wet weather conditions. This allowed for a better characterization of the critical condition than only addressing a single critical flow condition. Additionally for the Chollas Creek Metals TMDL project, a critical point was selected at the mouth of the Chollas Creek watershed. A critical point is a location in an impaired water body that is selected based on high pollutant loads predicted at that location. Not only does the Clean Water Act (CWA) require that critical conditions be taken into account [40 CFR 130.7(c)], but both the identification of dry and wet weather critical flow conditions and the Chollas Creek watershed's critical point are useful in conservatively assessing impairments to Water Quality Objectives (WQOs) and in directing implementation of load reduction strategies. However, although this critical point for water quality assessment is utilized for TMDL analysis, compliance to WQOs must be assessed and maintained for all segments in the Chollas Creek watershed to ensure that beneficial uses are protected.

1.3. Constituents

Another important consideration in model selection and application is the constituent(s) to be assessed. Choice of state variables is a critical part of model implementation. The more state variables included, the more difficult the model will be to apply and calibrate. However, if key state variables are omitted from the simulation, the model might not simulate all necessary aspects of the system and might produce unrealistic results. A delicate balance must be met between minimal constituent simulation and maximum applicability.

The focuses of the Chollas Creek Metals TMDL project is assessing the copper, lead, and zinc loads that cause impairment to the beneficial uses of the Chollas Creek watershed. These metal loads can be estimated by combining the flow rates and concentration. Factors affecting the concentration of metals include hardness, pH, and available sediment. Metal concentrations in the water column are also influenced by in-stream losses and settling. In-stream metal dynamics can be extremely complex, and accurate estimation of concentrations relies on a host of interrelated environmental factors. The available data provided few insights into which other factors might be most influential on metal behavior for the model.

1.4. Regulatory Criteria

A properly designed and applied model provides the source analysis component of the Chollas Creek Metals TMDL project. The Regional Water Quality Control Board, San Diego Region's (Regional Board) Basin Plan establishes, for all waters in the San Diego region, the beneficial uses to be protected, the WQOs that those uses, and an implementation plan that

achieves those objectives (Regional Board, 1994). For the watershed source analysis and the implementation plan, it is also important that the modeling platform enable examination of gross land use loading as well as in-stream concentration.

1.5. Application of San Diego Regional Hydrologic Model for both Dry and Wet Weather Models

The San Diego regional hydrologic model described in this appendix was originally designed to simulate dry weather bacteria concentrations in the San Diego region, as described in *Bacteria TMDLs for Beaches and Inland Surface Waters of the San Diego Region – DRAFT* (Tetra Tech, Inc., 2004). Because the flow model was based on data from the San Diego region and has robustly calibrated and validated measured parameters for the San Diego region, it is appropriate to use for the Chollas Creek Metals TMDL project. This single set of parameters was calibrated and validated over a diverse geographic (includes mountainous and coastal regions as well as highly urbanized and open areas) and temporal scale (includes extreme dry and wet weather periods), and can therefore be applied to many of the ungaged streams within the San Diego region, including Chollas Creek.

Without this regional set of parameter values, a watershed model would be unfeasible for the source analysis support needed for the Chollas Creek Metals TMDL project. By applying the regionally calibrated hydrology parameter values to the updated watershed delineations and land use reclassifications for the Chollas Creek watershed, flow was simulated for the watershed. Current analyses utilize the calibrated flow parameters from the San Diego regional hydrologic model, while considering additional local information. This appendix describes model set-up, calibration, and validation of the San Diego regional hydrologic model, emphasizes why this regional model is applicable to the Chollas Creek watershed, and notes the modifications that were made to adapt the model for the Chollas Creek watershed.

1.6. Model Calibration and Validation

After any model is configured, model calibration and validation must be performed to ensure the natural environment is represented as accurately as possible. For watershed modeling, this is generally a two-phase process, with hydrology (flow rate) calibration and validation completed before repeating the process for water quality (pollutant concentration). Upon completion of the calibration and validation at selected locations, a calibrated dataset containing parameter values for each modeled land use and pollutant was developed.

2. Estimated Existing Loads for Dry and Wet Weather Conditions

2.1. Explanation of Dry and Wet Weather Conditions

A distinction is made between dry and wet weather conditions because the sources and amounts of metals vary between the two scenarios and implementation measures will be specific to these conditions. Existing copper, lead, and zinc loads were estimated for both dry and wet weather conditions to provide year-round representation of the Chollas Creek watershed.

Utilizing separate approaches for dry and wet weather conditions ensured that the Chollas Creek Metals TMDL project addressed the variable flow patterns in the Chollas Creek watershed with an appropriate methodology. A flow-based cutoff to separate dry and wet weather conditions, as opposed to a dry and wet weather season approach, was applied to accurately capture rainfall events and sustained dry periods throughout the year. The dry weather flow approach uses a steady-state model to estimate existing loads during dry periods that are not addressed through the wet weather flow rate approach.

Before existing loads for dry and wet weather conditions could be estimated, the two conditions need finite definitions. Dry weather conditions are based on dry weather days that were selected based on the criterion that less than 0.2 inch of rainfall was observed on each of the previous three days¹. A wet weather condition was characterized as any flow greater than the dry weather condition criteria as predicted by the dry weather model based on the definition above.

2.2. Dry and Wet Weather Critical Flow Conditions

The dry weather critical flow condition was based on predictions of steady-state flows, which were derived through modeling analysis of average dry weather flows observed in the San Diego region. The dry weather critical condition was based on the prediction of steady-state flows. As described in section 3, regionally calibrated model parameters were developed through a modeling analysis of average dry weather flows observed in Aliso Creek (2001), Rose Creek (2001-2002), and Tecolote Creek (2001-2002). These parameters were applied to the Chollas Creek watershed to determine the watershed-specific critical dry weather flow condition.

To ensure protection of the Chollas Creek watershed during wet weather conditions, a critical flow condition was selected based on identification of the 93rd percentile of annual rainfall observed over the past 14 years (1990 through 2003) at multiple rainfall gages in the San Diego region. Essentially the critical flow condition was based on the wettest year of the past 14 years. This resulted in selection of 1993 as the critical wet year for assessment of wet weather conditions. This critical flow condition was consistent with studies performed by the Southern California Coastal Research Project (SCCWRP), where a 90th percentile year was selected based on rainfall data for the Los Angeles Airport from 1947 to 2000, also resulting in selection of 1993 as the critical wet year (Regional Water Quality Control Board, Los Angeles Region (LARWQCB), 2002).

2.3. Estimated Existing Annual Loads from Dry and Wet Weather Models

¹ This definition comes from the California Department of Environmental Health's general advisory that is issued to alert the public of ocean and bay water contamination by urban runoff. It is also supported by CFR section 122.21 and section 122.26.

According to the CWA [40 CFR 130.2 (i) and 40 CFR 130.7 © (1)] a TMDL document must analyze all sources, and the magnitude and location of the sources. In order to comply with the CWA, both the dry and wet weather models were used to estimate existing annual loads of copper, lead, and zinc. In addition the mass loadings estimated from the model outputs also offer support for the implementation plan. Relative amounts of mass loadings for dry and wet weather conditions can identify where more serious problems occur and on which subwatersheds or land uses efforts should be concentrated. For example, for all three metals, freeways and commercial/institutional land uses have the highest relative loading contributions. Responsible parties may want to concentrate efforts on controlling metal sources in these areas.

The simulated flow rate was combined with average in-stream dry weather concentrations for dissolved copper, lead, and zinc in order to estimate basin-wide existing loads for each metal (Table 1). The estimated loads for the dry weather critical flow conditions were the same as the average estimated loads for the dry weather typical condition because the dry weather metal concentration could not be simulated due to limited observed data for calibration. The estimated existing loads for the wet weather critical flow rate condition and the average estimated existing loads (1990-2003) for the wet typical weather condition are provided in Table 2 and Table 3 for each metal. All estimated existing loads are calculated at the mouth of the Chollas Creek watershed, which is the critical point.

Table 1. Estimated existing loads (grams per year) for the dry weather critical flow condition and average estimated existing loads for the dry weather typical condition at the critical point

Copper (dissolved)	Lead (dissolved)	Zinc (dissolved)
692	168	986

Table 2. Estimated existing loads (grams per year) for the wet weather critical flow rate condition at the mouth of the Chollas Creek watershed

Copper (dissolved)	Lead (dissolved)	Zinc (dissolved)
984,549	705,142	5,993,255

Table 3. Average estimated existing loads (grams per year) for the average wet weather condition for 1990 through 2003 at the critical point.

Copper (dissolved)	Lead (dissolved)	Zinc (dissolved)
232,137	194,007	1,326,407

2.4. Model Assumptions/Limitations

While highly beneficial tools for analyzing surface runoff pollution problems, all mathematical models are based on assumptions or inferences made about the processes and systems being simulated, which must be considered (Charbeneau & Barrett, 1998; Loague, Corwin, & Ellsworth, 1998; Nix, 1994; Tim & Jolly, 1994). These limitations include the steep learning curve for model use, the accuracy of the mathematical equations, and inadequacies and assumptions of the input data (Charbeneau & Barrett, 1998; Nix, 1994; Tim & Jolly, 1994). Model users must keep in mind that a model is a tool; and while it can extract information, it cannot overcome data inadequacies or assumptions. The specific assumptions made with the modeling approach used for in the Chollas Creek Metals TMDL project include but are not limited to the following:

2.4.1. General Model Assumptions

- The critical point was assumed to be at the mouth of the Chollas Creek watershed.
- Water quality monitoring data were not sufficient to fully characterize all sources of metals in the Chollas Creek watershed.
- The limited data available provide few insights into which other factors might be most influential on metal behavior for the model

2.4.2. Wet Weather Model Assumptions

The following assumptions are relevant to the Loading Simulation Program written in C++ (LSPC) model developed to simulate wet-weather sources of metals in Chollas Creek.

- *Source Representation* - All sources can be represented through build-up/wash-off of metals from specific land use types.
- *Flow* - Because modeled and observed flow ranges are similar, a simulation program hydrology model flow rate results were considered representative of flow in the Chollas Creek watershed. Differences can be explained by localized events, and until additional flow data become available, further calibration is not possible, nor warranted.
- *Water Quality Data* - Observed water quality data, unlike stream flow data, are usually not continuous; thus making time-series comparisons difficult and reducing the accuracy of the water quality model calibration.
- *General LSPC/HSPF Model Assumptions* - Many model assumptions are inherent in the algorithms used by the LSPC watershed model and are reported extensively in Bicknell et al. (1996).
- *Land Use* - The San Diego Association of Governments (SANDAG) land use GIS dataset is assumed representative of the current land use areas. For areas where significant changes in land use have occurred since the creation of these datasets, model predictions may not be representative of observed conditions.
- *Stream Representation* - Each delineated subwatershed was represented with a single stream assumed to be a completely mixed, one-dimensional segment with a trapezoidal cross-section.
- *Hydrologic Modeling Parameters* - Hydrologic modeling parameters were developed during previous modeling studies in Southern California (e.g., LA River, San Jacinto

River) and refined through calibration to stream flow data collected in the San Diego region. Through the calibration and validation process (reported in the Bacteria TMDLs for the San Diego Region), a set of modeling parameters were obtained specific to land use and hydrologic soil groups. These parameters are assumed to be representative of the hydrology of the Chollas Creek watershed, which is presently ungaged and therefore unverified.

- *Water Quality Modeling Parameters* - Dynamic models require a substantial amount of information regarding input parameters and data for calibration purposes. All sources of metals from watersheds are represented in the LSPC model as build-up/wash-off from specific land use types. Limited data are currently available in the San Diego region to allow development of unique modeling parameters for simulation of build-up/wash-off, so initial parameters values were obtained from land use-specific storm water data in the Los Angeles region. These build-up/wash-off modeling parameters were refined during the calibration and validation process in which observed data from Chollas Creek were compared with the model predicted values.
- *Lumped Parameter Model Characteristic* - LSPC is a lumped-parameter model and is assumed to be sufficient for modeling transport of flows and metal loads from watersheds in the region. For lumped parameter models, transport of flows and metal loads to the streams within a given model subwatershed cannot consider relative distances of land use activities and topography that may enhance or impede time of travel over the land surface.
- *First-order Losses* - Each stream is modeled assuming first-order loss of metals.
- *Wet-weather Critical Condition* – The critical wet-weather condition was selected based on identification of the 93rd percentile of annual rainfalls observed over the past 12 years (1990 through 2002) at multiple rainfall gages in the San Diego region. This resulted in selection of 1993 as the critical wet year for assessment of wet weather loading conditions. This condition was consistent with studies performed by SCCWRP, where a 90th percentile year was selected based on rainfall data for the Los Angeles Airport (LAX) from 1947 to 2000, also resulting in selection of 1993 as the critical year (LARWQCB, 2002).

2.4.3. Dry Weather Model Assumptions

The following assumptions are relevant to the watershed modeling system developed for simulation of steady-state dry-weather flows and sources of metals.

- *Limited Dry Weather Data* - Because there were only seven in-stream dry weather metal concentration data points in the Chollas Creek watershed, copper, lead, and zinc concentrations could not be simulated. Therefore, land use specific loadings and more detailed analyses could not be calculated.
- *Stream Representation* - This predictive model represents the stream network as a series of plug-flow reactors, with each reactor having a constant, steady state flow and pollutant load.
- *Flow Condition* - These constant flows were assumed representative of the average flow caused by various urban land use practices (e.g., runoff from lawn irrigation or sidewalk washing).

- *Channel Geometry* - Channel geometry during low-flow, dry-weather conditions is assumed to be represented appropriately using equations derived from flows and physical data collected at 53 U.S. Geological Survey (USGS) stream gages in Southern California.
- *Steady-state Model Configuration* - Although dry-weather flows vary over time for any given stream, for prediction of average conditions in the stream, flows were assumed to be steady state.
- *Plug Flow Model Configuration* - Plug flow reaction kinetics were assumed sufficient in modeling dry-weather, steady state stream routing.
- *Sources for Characterization of Dry-weather Conditions* - Data used for characterization of dry-weather flows were assumed representative of conditions throughout the region.
- *Methods for Characterization of Dry-weather Conditions* - The equations derived through multivariable regression analyses were assumed sufficient to represent the dry-weather flows as a function of land use and watershed size. This assumption was verified through model calibration and validation reported.
- *Stream Infiltration* - Losses of volume through stream infiltration were modeled assuming infiltration rates were constant for each of the four hydrologic soil groups (A, B, C, and D²). Infiltration rates were based on literature values and refined through model calibration and validation. The resulting infiltration rates were 1.368 inches per hour (in/hr) (Soil Group A), 0.698 in/hr (Soil Group B), 0.209 in/hr (Soil Group C), and 0.084 in/hr (Soil Group D). These infiltration rates are within the range of values found in literature (Wanielis et al., 1997). These infiltration rates are assumed representative for all streams studied in the region within each hydrologic soil group.
- *Dry-weather Critical Condition* - The critical dry period was based on predictions of steady-state flows based on results of analysis of average dry-weather flows observed in Aliso Creek, Rose Creek, and Tecolote Creek. Dry-weather days were selected based on the criterion that less than 0.2 inch of rainfall was observed on each of the previous 3 days.

3. Dry Weather Model

During dry weather conditions, many streams exhibit a sustained base flow even if no rainfall has occurred for a significant period to provide storm water runoff or groundwater flows. These sustained flows are generally understood to result from various urban land use practices (e.g. lawn irrigation runoff, car washing, and sidewalk washing) and are referred to

² Group A Soils have low runoff potential and high infiltration rates even when wet. They consist chiefly of sand and gravel and are well drained to excessively-drained. Group B Soils have moderate infiltration rates when wet and consist chiefly of soils that are moderately-deep to deep, moderately- to well-drained, and moderately coarse textures. Group C Soils have low infiltration rates when wet and consist chiefly of soils having a layer that impedes downward movement of water with moderately-fine to fine texture. Group D Soils have high runoff potential, very low infiltration rates and consist chiefly of clay soils. These soils also include urban areas (USDA, 1986).

as urban runoff. As these urban runoffs travel across land areas (e.g. lawns and other urban surfaces), accumulated metal loads are carried from these areas to receiving waterbodies.

The dry weather model was used to estimate the flow rates of urban runoff in the Chollas Creek watershed. The average metal concentrations were used to estimate the existing metal concentrations that end up in Chollas Creek from urban runoff transportation of metal loads. Figure 1 is a visual representation of how the model outputs were used. Because there were only seven in-stream dry weather metal concentration data points in the Chollas Creek watershed, copper, lead, and zinc concentrations could not be simulated. The simulated flow values from a San Diego regional hydrologic model were instead combined with average in-stream dry weather metal concentrations for dissolved copper, lead, and zinc to calculate estimated basin-wide loads for each metal (Table 1).

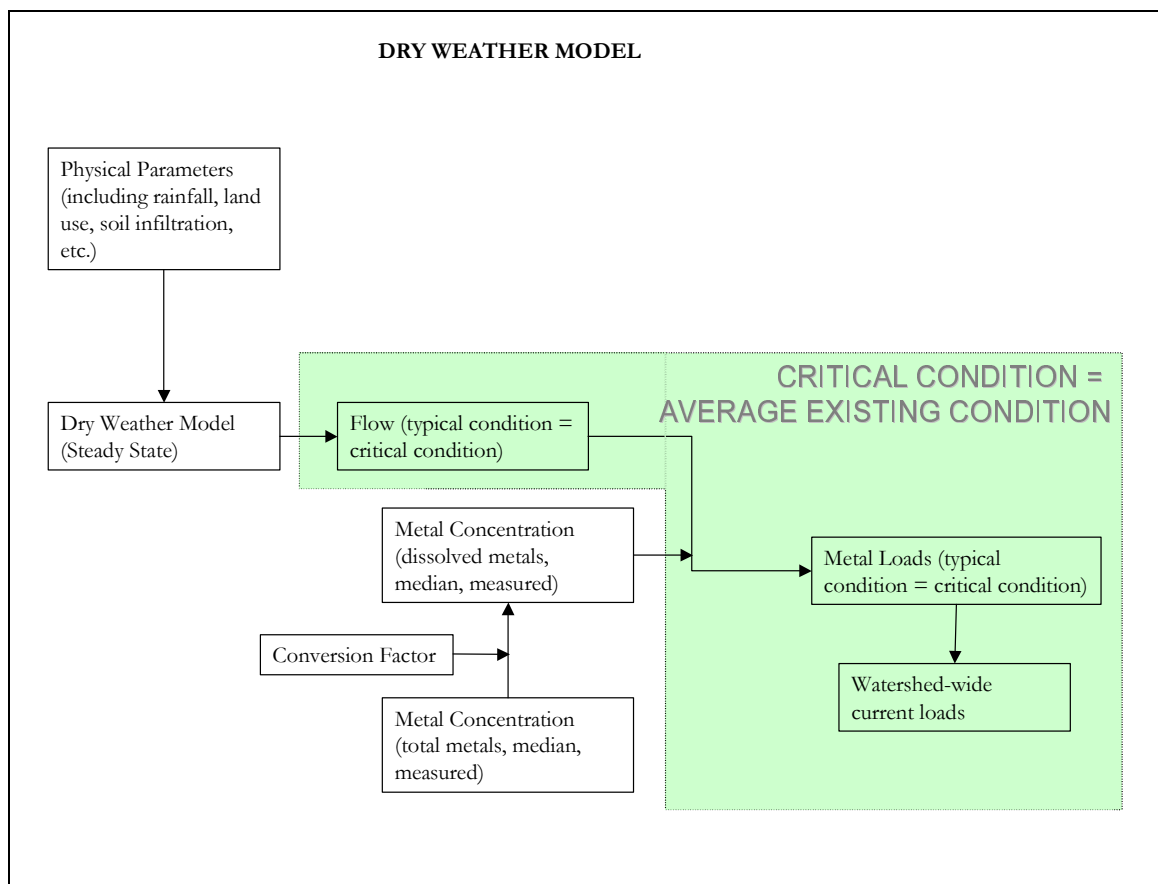


Figure 1. Dry weather model outputs.

3.1 Dry Weather Modeling Details

To estimate sources from dry weather urban runoff, a steady-state spreadsheet was developed for the San Diego region to model dry weather flow in the watershed. However, because limited in-stream dry weather metal concentration data were available for model calibration and validation, copper, lead, and zinc concentrations could not be simulated and average

values from available data were used. The calibrated, low flow, steady-state model was used to estimate flows during dry weather conditions. These constant flows were assumed representative of the average flow caused by various urban land use practices (e.g., runoff from lawn irrigation or sidewalk washing).

3.1.1 Dry Weather Model Use of the Chollas Creek Watershed Representation

The initial step in this watershed-based analysis was to clearly define the watershed boundary. Therefore, before the model could be configured, an appropriate scale for analysis was determined. Model subwatersheds were delineated based on CALWTR 2.2, a standard nested watershed delineation scheme, watersheds, stream networks, locations of flow and water quality monitoring stations, consistency of hydrologic factors, and land use uniformity. The subwatersheds, soil types, and stream lengths used in the dry weather model were identical to those described in the wet weather model. Figure 2 provides a schematic of the stream network for the Chollas Creek watershed, which includes model segment connectivity, used for the Chollas Creek Metals TMDL project. Section 4.2 also provides a more detailed discussion of the watershed representation used for the wet weather model.

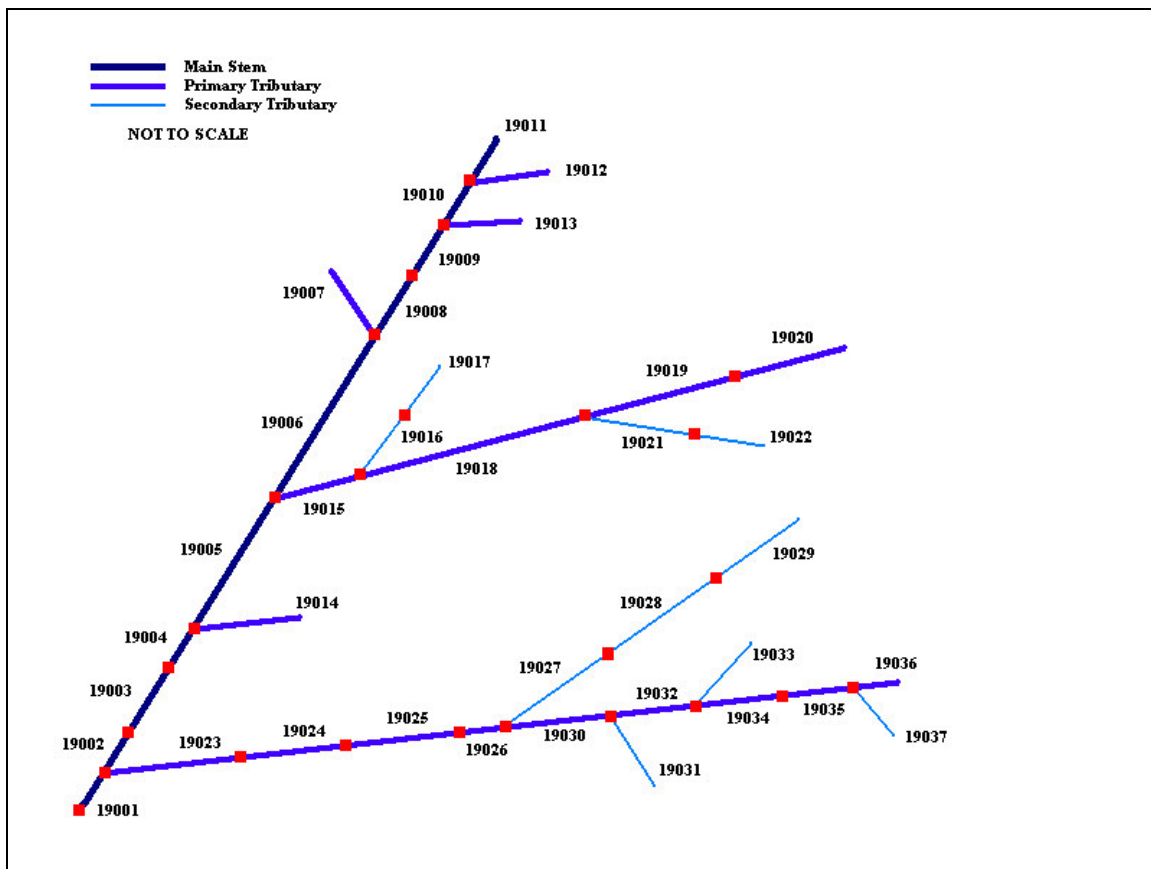


Figure 2. Schematic of model segments (indicated by subwatershed identification numbers) for Chollas Creek and its tributaries. Each segment is identified with a model number.³

³ See Figure 11 for the segments as they appear on a map of the Chollas Creek watershed.

3.1.2. Channel Geometry

Precise channel geometry data were not available for the modeled stream segments; therefore, stream dimensions were estimated from analysis of observed data from other areas. Analyses were performed on flow data and associated stream dimension data from 53 USGS gages throughout Southern California. For this analysis, all flow less than 15 cubic feet per second (ft³/s) was assumed to represent dry weather flow conditions. Using these dry weather flow data, the relationship between flow and cross-sectional area was estimated ($R^2 = 0.51$). The following regression equation describes the relationship between flow and cross-sectional area:

$$A = e^{0.2253 \times Q}$$

where:

A = cross-sectional area, feet squared (ft²)

Q = flow, cubic feet per second (ft³/s)

In addition, data from the USGS gages were used to determine the width of each segment based on a regression between cross-sectional area and width. The relationship with the greatest correlation ($R^2 = 0.75$) was based on the natural logarithms of each parameter. The following regression equation describes the relationship between cross-sectional area and width:

$$LN(W) = (0.6296 \times LN(A)) + 1.3003 \quad \text{or} \quad W = e^{((0.6296 \times LN(A)) + 1.3003)}$$

where:

W = width of model segment (ft)

A = cross-sectional area (ft²)

3.1.3. Steady-State Mass Balance Overview

To represent the linkage between dry weather source contributions and in-stream response, a steady-state mass balance model was developed to simulate transport of pollutants in the impaired stream segment. This predictive model represents the stream network as a series of plug-flow reactors, with each reactor having a constant, steady state flow and pollutant load. A plug-flow reactor can be thought of as an elongated rectangular basin with a constant level in which advection (unidirectional transport) dominates (Figure 3).

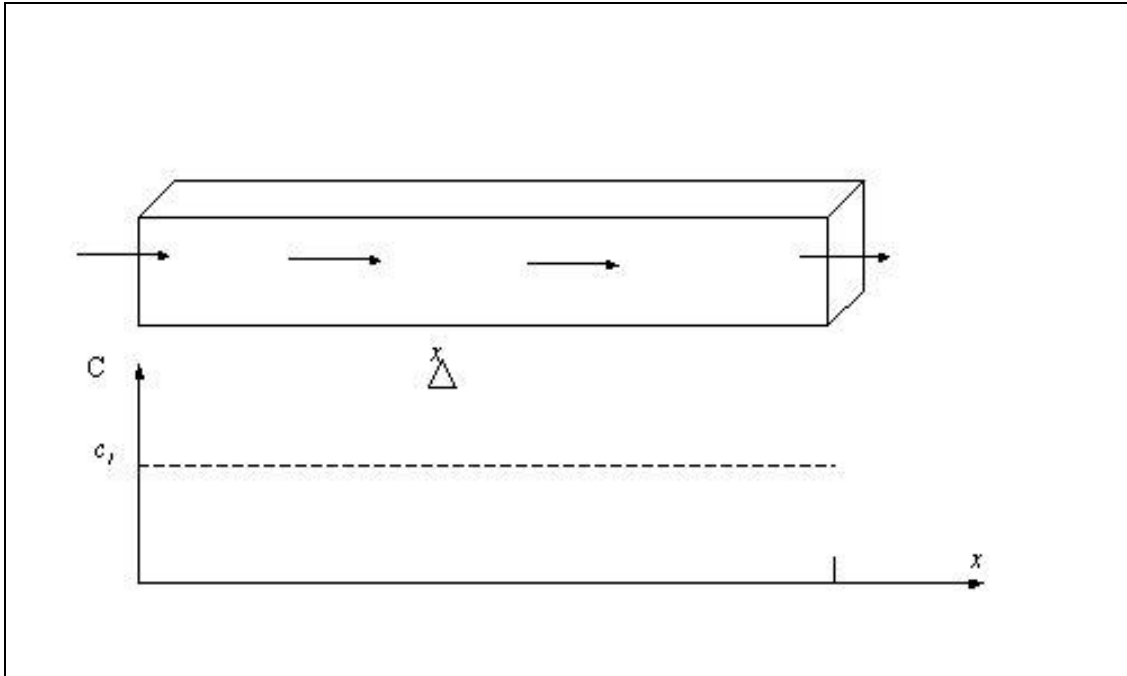


Figure 3. Theoretical plug-flow reactor. See following equations for definition of variables.

This modeling approach relies on basic segment characteristics, which include flow, width, and cross-sectional area. Model segments are assumed to be well-mixed laterally and vertically at a steady-state condition (constant flow input). Variations in the longitudinal dimension determine changes in flow and pollutant concentrations. A “plug” of a conservative substance introduced at one end of the reactor will remain intact as it passes through the reactor. The initial concentration of a pollutant from multiple sources can be represented based on empirically derived inflows as a single input at the injection point. Each reactor defines the mass balance for the pollutant and flow. At points further downstream, the concentration can be estimated based on first-order loss and mass balance.

3.1.4. Dry Weather Model Equations

There are two core equations used in the dry model, one to represent the mass balance and one to represent the loss of concentration downstream.

A mass-balance of the watershed load and, if applicable, of the load from the upstream tributary were performed to determine the change in concentration. This is represented by the following equation:

$$C_o = \frac{Q_r C_r + Q_t C_t}{Q_r + Q_t}$$

where:

Q = flow (ft³/s)
 C = concentration

In the previous equation, Q_r and C_r refer to the flow and concentration from the receiving watershed and Q_t and C_t refer to the flow and concentration from the upstream tributary. The concentration estimated from this equation was then used as the initial concentration (C_0) in the loss equation for the receiving segment.

To describe instream losses, a first order rate equation was derived. An initial concentration (C_0) for inflow was set as an upstream boundary condition. The final water column concentration (C) in a segment can be estimated using the loss equation given below:

$$\frac{dc}{dt} = -kc \quad \text{or} \quad C = C_0 e^{-kt} = C_0 e^{-\left(k \frac{x}{u}\right)}$$

where:

- C_0 = initial concentration
- C = final concentration
- k = loss rate (1/day)
- x = segment length (miles)
- u = stream velocity (miles per day)

3.2. Dry Weather Model Use of a San Diego Regional Hydrologic model

The San Diego regional hydrologic model used estimates of subwatershed inflows obtained through analysis of available data. Data collected as part of detailed monitoring efforts of Aliso Creek (performed by the Orange County Public Facilities and Resources Department and the Orange County Public Health Laboratory) and of Rose Creek and Tecolote Creek (performed by the City of San Diego) were analyzed to estimate dry weather flow data. Information from these studies was assumed sufficient for use in characterizing dry weather flow conditions for the entire study area.

For each of the detailed studies, flow data were collected throughout the year at stations within the watersheds (27 stations for Aliso Creek, 3 stations for Rose Creek, and 2 stations for Tecolote Creek). The watersheds were delineated to each sampling location. Analyses were performed to determine whether there is a correlation between the respective land use types and average dry weather flow data collected at the mouth of each subwatershed.

The results of the analyses showed good correlation between flow and commercial/institutional, open space, and industrial/transportation land uses ($R^2 = 0.78$). The following equation was derived from the analysis:

$$Q = (A_{1400} \times 0.00168) + (A_{4000} \times 0.000256) - (A_{1500} \times 0.00141)$$

where:

- Q = flow (ft³/s)
- A_{1400} = area of commercial/institutional (acres)
- A_{4000} = area of open space, including military operations (acres)
- A_{1500} = area of industrial/transportation (acres)

The empirical equation presented above that represented water quantity associated with dry weather urban runoff from various land uses can be used to predict flow. Figure 4 shows the flow predicted by the above equation compared to observed data for Aliso Creek, Rose Creek, and Tecolote Creek.

Overall, the statistical relationship established between each land use area and flow showed good correlation with the observed flow data. To improve model fit, model calibration and validation were conducted.

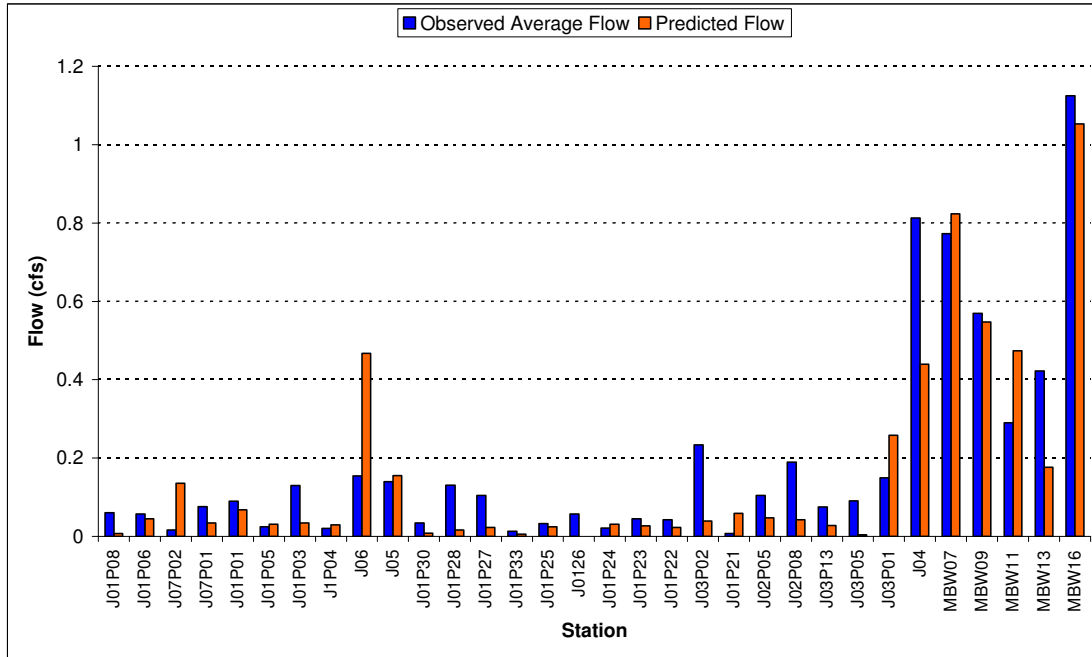


Figure 4. Predicted and observed flows in Aliso Creek, Rose Creek, and Tecolote Creek indicated by station numbers (Tetra Tech, Inc., 2004).

3.2.1. Calibration and Validation of the San Diego Regional Hydrologic model

Model calibration was performed using data from Aliso Creek and Rose Creek. Calibration involved the adjustment of infiltration rates to reflect observed in-stream flow conditions. Following model calibration, a separate validation process was undertaken to verify the predictive capability of the model in other watersheds. Table 4 lists the sampling locations used in calibration and validation, along with their corresponding watershed identification number from the San Diego regional hydrologic model. Figure 5 shows the sampling locations and their proximity to the Chollas Creek watershed. The model results presented in the next sections, especially the model calibration and validation, directly apply to the Chollas Creek watershed modeling effort because the Chollas Creek watershed is within the San Diego region.

Table 4. Sampling location for calibration and validation. (Tetra Tech, Inc., 2004)

Calibration – Flow		Validation – Flow
--------------------	--	-------------------

Watershed	Sampling Location	Watershed	Sampling Location	Watershed	Sampling Location	Watershed	Sampling Location
208	J01P22	214	J01P01	1602	MBW17	1701	MBW06
209	J01P23	215	J01TBN8	1603	MBW15	1702	MBW07
210	J01P28	219	J04	1605	MBW11	1703	MBW10
211	J01P27	220	J03P13	1606	MBW13	1704	MBW08
212	J06	221	J03P01	1607	MBW24	1705	MBW09
213	J01P05	1601	MBW20			403	USGS
							11047300

Watersheds beginning with a "2" are located in Aliso Creek, with a "4" are in San Juan Creek, with a "16" are in Rose Creek and with a "17" are in Tecolote Creek.

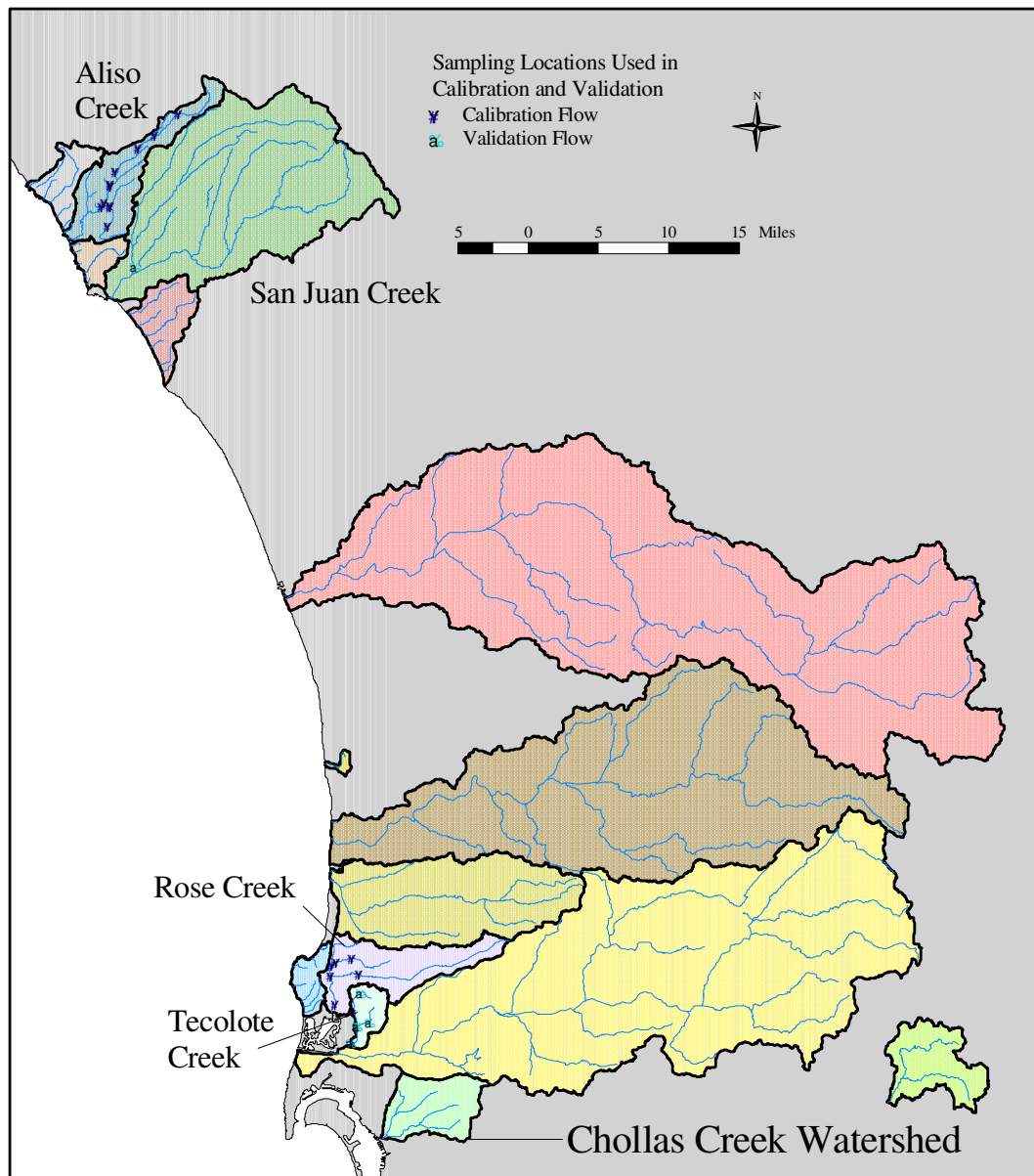


Figure 5. Sampling locations used for San Diego regional hydrologic model calibration and validation. (Tetra Tech, Inc., 2004)

3.2.2. San Diego Regional Hydrologic Model Calibration and Validation Results

Infiltration rates vary by soil type and model configuration included identifying a soil type for each subwatershed. Stream infiltration was calibrated by adjusting the infiltration rate. This rate was adjusted for each soil type within ranges identified from literature values (USEPA, 2000a). The goal of calibration was to minimize the difference between average observed flow and modeled flow at each calibration station location (Table 4). The model closely predicted observed flows and the calibration results are graphically presented in Figure 6.

The calibrated infiltration rates were 1.368 in/hr for Soil Group A, 0.698 in/hr for Soil Group B, 0.209 in/hr for Soil Group C, and 0.084 in/hr for Soil Group D. The infiltration rates for Soil Groups B, C, and D fall within the range of values described in the literature. The calibrated rate for Soil Group A is below the range identified in Wanielisata et al. (1997); however, Soil Group A is not present in the Chollas Creek watershed, which is dominated by Soil Groups C and D.

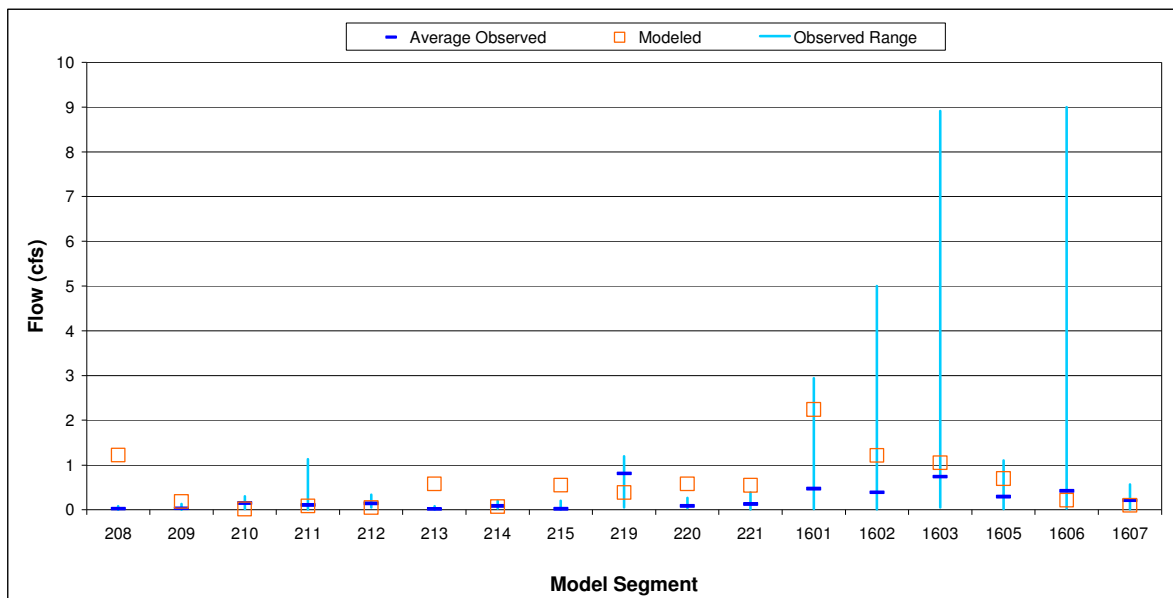


Figure 6. Calibration results of modeled versus observed flow. Model segment numbers are from the San Diego regional hydrologic model. (Tetra Tech, Inc., 2004)

Subsequent to model calibration, the model was validated using six stations in the San Juan Creek and Tecolote Creek Watersheds. (Table 4) The model-predicted flows were within the observed ranges of dry weather flows (Figure 7), demonstrating very good overall model fit.

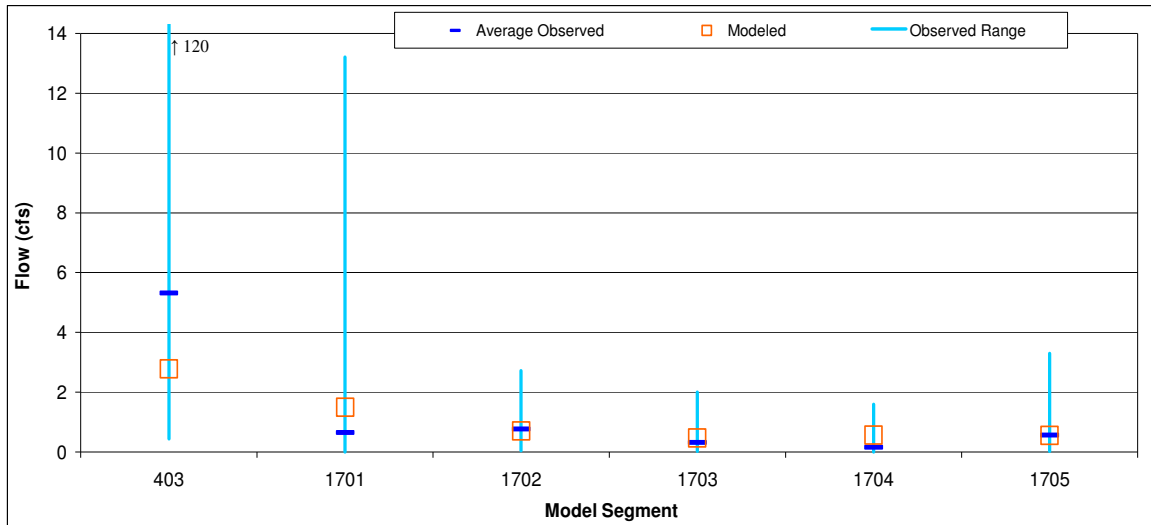


Figure 7. Validation results of modeled versus observed flow. Model segment numbers are from the San Diego regional hydrologic model. (Tetra Tech, Inc., 2004)

3.3. Summary of the Dry Weather Model Results

The steady-state model is calibrated for flow; however, data were not adequate to model dry weather metal loads from specific sources. At a future time, additional water quality data could be readily incorporated into the model and then be used to estimate pollutant concentrations in Chollas Creek or to support load allocations for another TMDL project. At that time, the pollutant concentrations in each segment could be estimated using metals concentration data, an in-stream loss rate, stream infiltration, basic channel geometry, and flow rate data.

3.3.1. San Diego Regional Hydrologic Model Application

Per the equation in section 3.1.4, for each model segment in the Chollas Creek watershed mass balances were performed on the following: inflows from upstream segments, input from local surface runoff, stream infiltration and evaporation, and outflow. The resulting overall dry weather model flow rate for Chollas Creek was 2.28 cubic feet per second (cfs). There is currently only one observed flow value available for comparison with the San Diego regional hydrologic model flow results: a flow measurement of 1.0 cfs was recorded at the in-stream dry weather flow data sampling location DW298. The corresponding model output for this location was 1.33 cfs indicating that the model is consistent with the magnitude of the measured dry weather flow rate datum.

3.3.2. Use of Average In-Stream Metals Concentration

As mentioned before, the model is currently configured to simulate steady-state pollutant concentrations through a mechanism similar to that for flow. Specifically, concentrations can be estimated in each reactor, or segment, using water quality data, a loss rate, basic channel geometry, and flow. Loss rates, which can be attributed to settling and other environmental conditions, were modeled as first-order. Model calibration and validation can be performed

by adjusting the rate of in-stream loss so that the predicted concentrations more closely match the observed data.

The amount of available dry weather metal concentration data currently prohibits the full utilization of the water quality, or concentration, component of this model, which has only been calibrated for bacteria to date. If sufficient data become available to establish a relationship between land use and metal concentrations during dry weather conditions, this feature of the model could be used to simulate source loadings and transport of pollutants in the Chollas Creek watershed and to help support other TMDL projects. Therefore, only the average observed concentrations were used to calculate the dry weather portion of the total estimates (Table 1).

4. Wet Weather Model

Wet weather source contributions of metal loads are generally associated with the wash-off of metal loads that have accumulated on the land surface. During rainfall events, these metal loads are delivered to the water body through creeks and storm water collection systems. Often, source contributions of metal, such as copper, lead, and zinc, loads can be linked to specific land use types that have higher relative accumulation rates, or are more likely to deliver metals to water bodies due to delivery through storm water collection systems. To assess the link between sources of metals and the impaired waters, a modeling system may be utilized that simulates the build-up and wash-off of metals and the hydrologic and hydraulic processes that affect delivery.

In order to model these processes for the Chollas Creek watershed, the watershed itself had to be delineated and categorized as subwatersheds with certain land uses. The land uses incorporated into the watershed model are described and illustrated in Appendix E, along with a table that identifies the subwatershed area associated with each land use. Next, observed rainfall data collected from the San Diego County storm water programs and other special studies were used to calibrate land use and soil-specific parameters in the watershed. Hydrology and water quality simulations were then performed for 1990 through 2003 to obtain modeled flow rates and concentrations, respectively. Transport processes of metal loads from the source to the impaired waterbodies were also simulated in the model with a first-order in-stream loss rate based on literature values. The model execution provided two outputs: estimated water quality concentration and estimated flows. These two outputs, in turn, can be used to estimate existing land use specific and subwatershed specific mass loads.

These estimated daily loads, which are based on model-predicted flows and metal concentrations, allowed for assessment of existing loading to the Chollas Creek watershed. To estimate the existing loads, first the maximum hourly total metal concentration was determined for each wet weather day predicted during the critical wet year. These maximum concentrations were then calculated as maximum daily values and then converted to the dissolved metal fraction by applying the appropriate acute conversion factor provided in the California Toxic Rule (CTR). Next, these dissolved metal values were multiplied by their respective average daily flow to estimate the existing dissolved metal load (Figure 8).

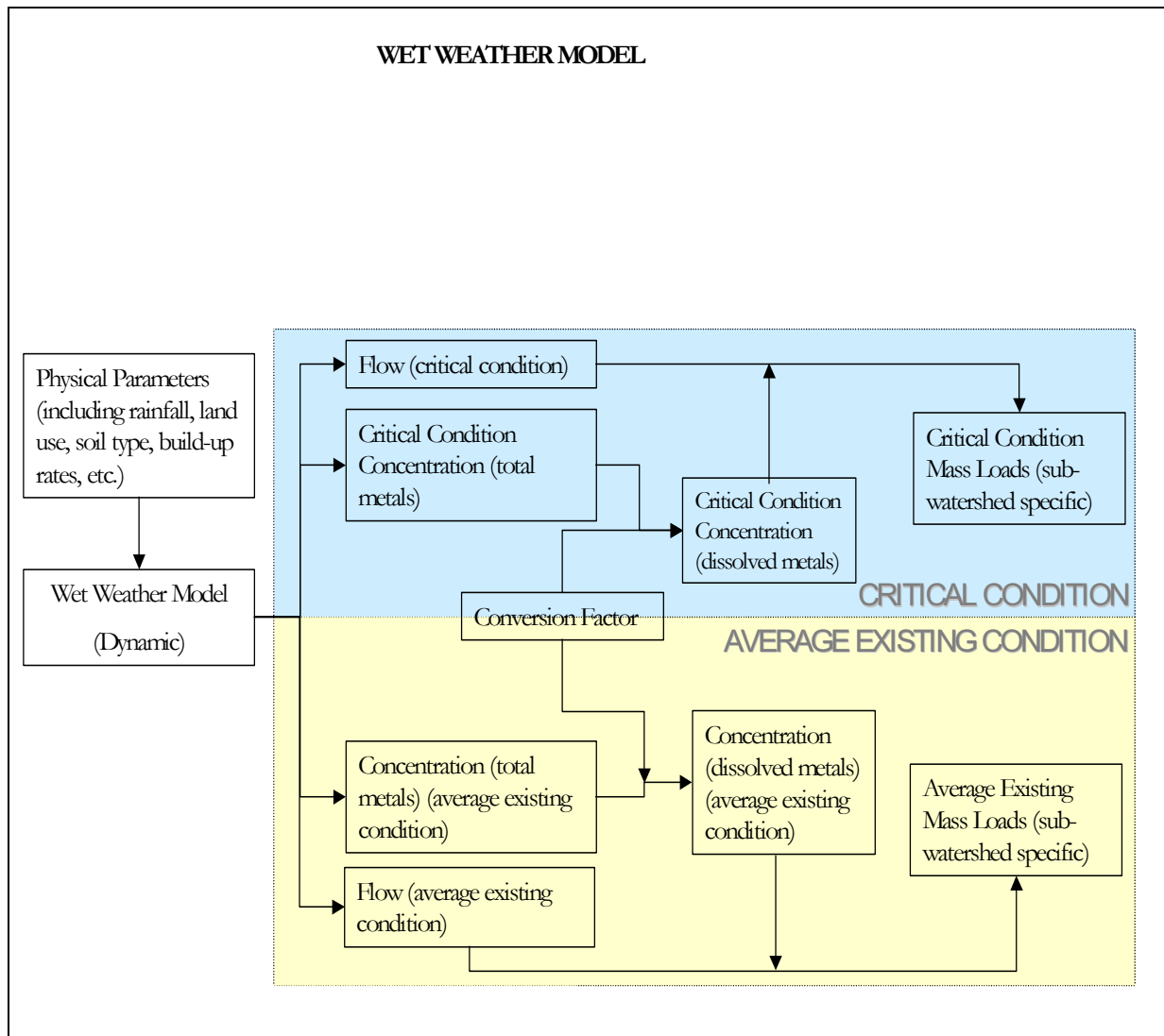


Figure 8. Wet weather model outputs.

4.1. Wet Weather Model Programs

Due to the complex nature of analyzing storm water contributions by drainage area associated with the Chollas Creek watershed, the source analysis for the Chollas Creek Metals TMDL project is based partly on a complex watershed model for wet weather conditions. This type of watershed analysis approach is a strategy for comprehensively addressing land management and water quality and quantity issues over an entire watershed. This approach is applicable to watersheds throughout the world because local information is taken into consideration. Such information includes the local geography and meteorological conditions.

The watershed model chosen to support the source analysis, which will in turn be used in the implementation plan, was the USEPA LSPC, a re-coded version of USEPA's Hydrological Simulation Program -FORTRAN (HSPF), which simulated the hydrologic processes and the metal loading to receiving waterbodies in the Chollas Creek watershed. A description of the model programs and the basic process of modeling used to support the Chollas Creek Metals TMDL project follows

4.1.1. HSPF Program

HSPF, an adaptation of the Stanford Watershed Model, was primarily developed to evaluate the effect of land use changes on water, sediment, and pollutant movement (Donigian, Imhoff, Bicknell, & Kittle, 1984). This model uses geographic and continuous meteorological data to compute stream flow and can then simulate both point and nonpoint source pollution through a wide range of complex mathematical equations. These equations represent surface and subsurface hydrologic conditions, including interflow and evapotranspiration, as well as water quality processes (Bicknell, Imhoff, Kittle, Jobes, & Donigian, 2001). Coefficients for these conditions and processes are manipulated during model calibration. HSPF is over 30 years old and has been extensively applied, despite its substantial learning curve (Whittemore, 1998). There have been hundreds of applications of HSPF all over the world, ranging from the 62,000 square mile Chesapeake Bay tributary area to a few-acre plot near Watkinsville, Georgia (USGS, 2002).

4.1.2. LSPC Program

LSPC is a program for dynamically modeling watersheds and is essentially a re-coded version of HSPF, which has further been integrated with a geographic information system (GIS), comprehensive data storage and management capabilities, and a data analysis/post-processing system into a convenient PC-based windows interface that dictates no software requirements. LSPC has been applied and calibrated in many Southern California waterbodies including the Los Angeles, San Gabriel, and San Jacinto Rivers and 20 watersheds in the San Diego region.

4.1.3. General Simulation Process

Understanding and modeling hydrologic and hydraulic processes provides the necessary decision support for TMDL development and implementation. A basic function of the model can be described in several steps:

- (1) **LSPC Execution.** This process involved launching LSPC, inputting necessary data, and performing initial model simulations.
- (2) **Comparison of Results.** Upon successful execution of LSPC, model results were compared with observed data and analyzed for accuracy and applicability.
- (3) **Parameter Adjustments for Model Calibration.** The analyses performed in step 2 determine which parameters, if any, should be altered in this step to more accurately predict the observed data.
- (4) **Simulation Runs for Model Calibration.** This step involved performing additional model runs with the adjusted parameter values.
- (5) **Model Validation.** This step involved testing the calibrated parameters using independent date ranges and gage locations.

Steps 2, 3, and 4 described above are an iterative process and were performed in order, but eventually terminated with an analysis of the model results. These intermediate steps were conducted until the model results achieved satisfactory agreement with the natural system. See Figures 9 and 10 for a visual representation.

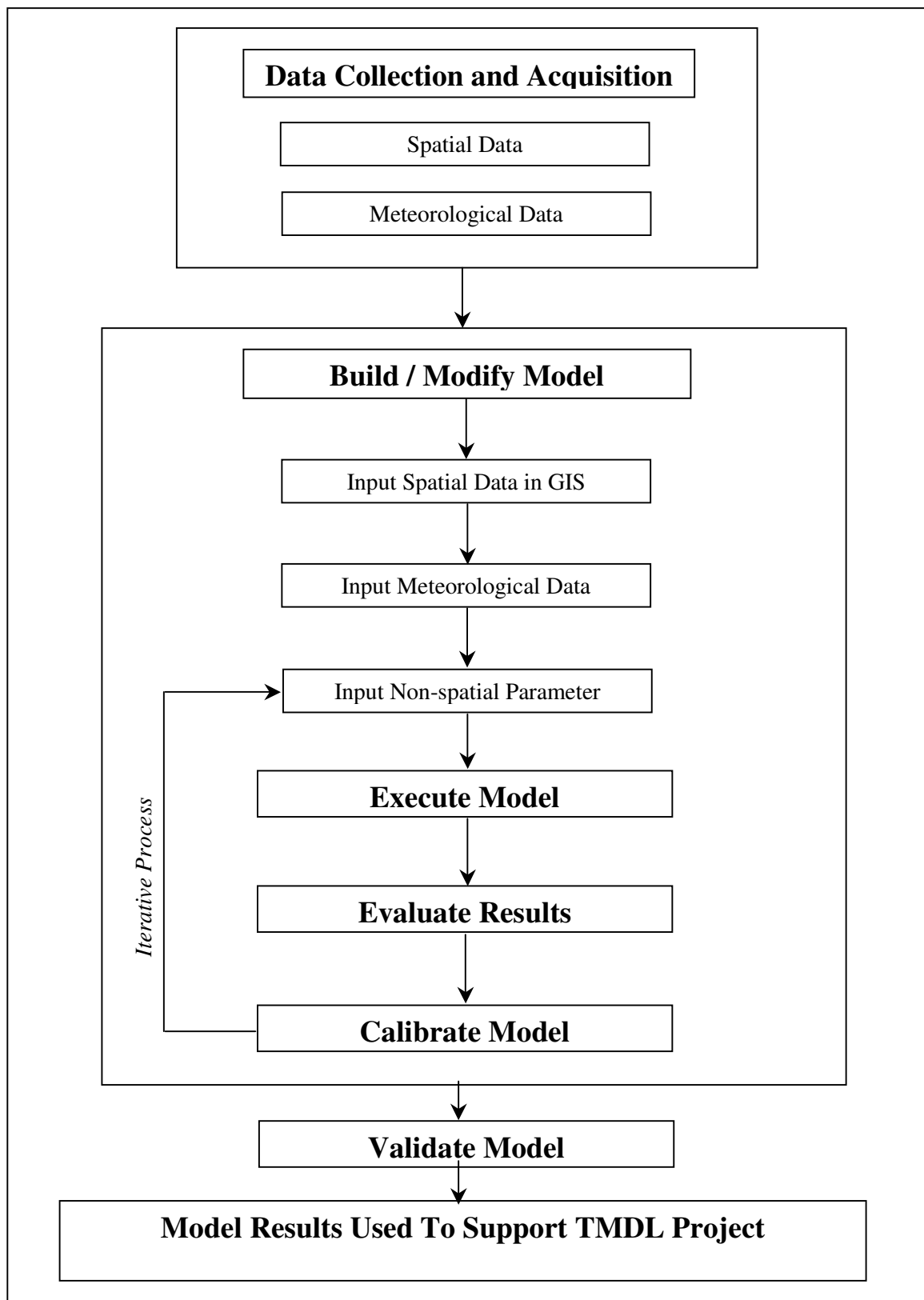


Figure 9. Overview of the methodology used.

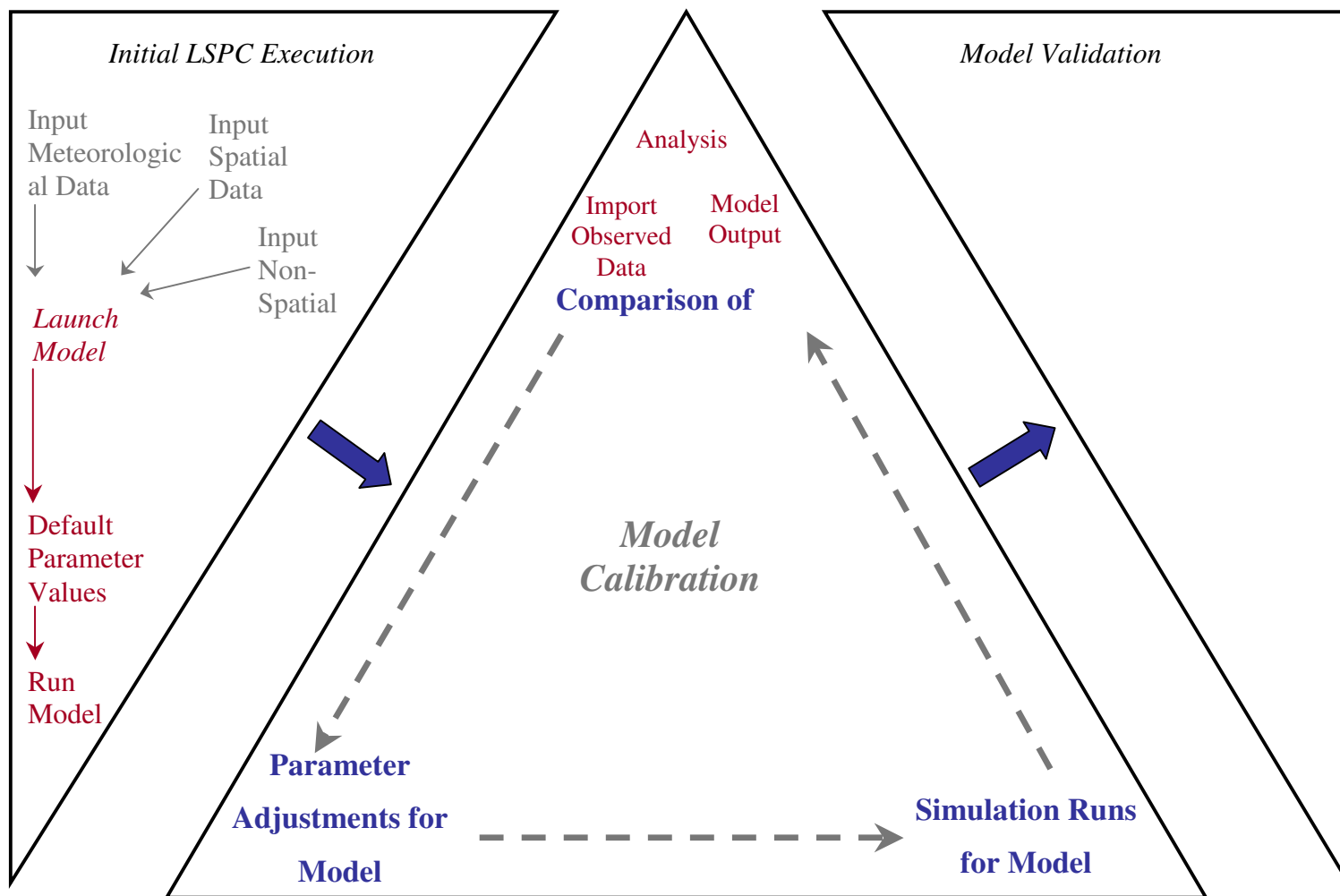


Figure 10. Hydrologic Simulation Program – Fortran (HSPF) modeling process

4.2. Wet Weather Model Details

Configuration of the watershed model involved consideration of four major components: water body representation, land use representation, meteorological data, hydrologic, and pollutant representation. These components provided the basis for the model's ability to estimate flow and pollutant loadings. Water body representation refers to LSPC modules or algorithms used to simulate flow and pollutant transport through streams and rivers. The land use representation provides the basis for distributing soils and pollutant loading characteristics throughout the basin. In addition to these components, meteorological data, hydrological representation and pollutants representation is very important. Meteorological data essentially drive the watershed model. Rainfall and other parameters are key inputs to LSPC's hydrologic algorithms. Hydrologic and pollutant representation refers to the LSPC modules or algorithms used to simulate hydrologic processes (e.g., surface runoff, evapotranspiration, and infiltration) and pollutant loading processes (primarily accumulation and wash-off). This section describes more of the specific details that were used in modeling the Chollas Creek watershed.

4.2.1. Wet Weather Model Water Body Representation

Each delineated subwatershed was represented with a single stream assumed to be completely mixed, one-dimensional segments with a trapezoidal cross-section. The National Hydrography Dataset (NHD) stream reach network for USGS hydrologic units 18070301 through 18070305 were used to determine the representative stream reach for each subwatershed. The Chollas Creek watershed is in the 18070304 USGS hydrologic unit.

Once the representative reach was identified, slopes were estimated based on digital elevation models (DEM) data and stream lengths measured from the original NHD stream coverage. In addition to stream slope and length, mean depths and channel widths are required to route flow and pollutants through the hydrologically connected subwatersheds. Mean stream depth and channel width were estimated using regression curves that relate upstream drainage area to stream dimensions. An estimated Manning's roughness coefficient of 0.2 was also applied to each representative stream reach.

4.2.2. Wet Weather Model Watershed Segmentation

As mentioned in section 3.1.1, the initial step in any watershed-based analysis is to clearly define the watershed boundary. A watershed is defined as a drainage basin, or an area of land in which all waters drain to a single river system (Heathcote, 1998). Watershed segmentation refers to the subdivision of watersheds into smaller, discrete subwatersheds for modeling and analysis. This subdivision was primarily based on the stream networks and topographic variability, and secondarily on the locations of flow and water quality monitoring stations, consistency of hydrologic factors, land use consistency, and existing watershed boundaries (based on CALWTR 2.2 watershed boundaries).

For this current model application, the Chollas Creek watershed was divided into thirty-seven separate sub-basins (Figure 11). These subwatersheds were based on the stream network and topographic data and were further delineated to each station where wet weather metal

concentration data was collected. Delineation to the water quality stations allows for direct comparison between model output and observed water quality data in order to evaluate what subwatersheds were sources of metal loads to The Chollas Creek watershed.

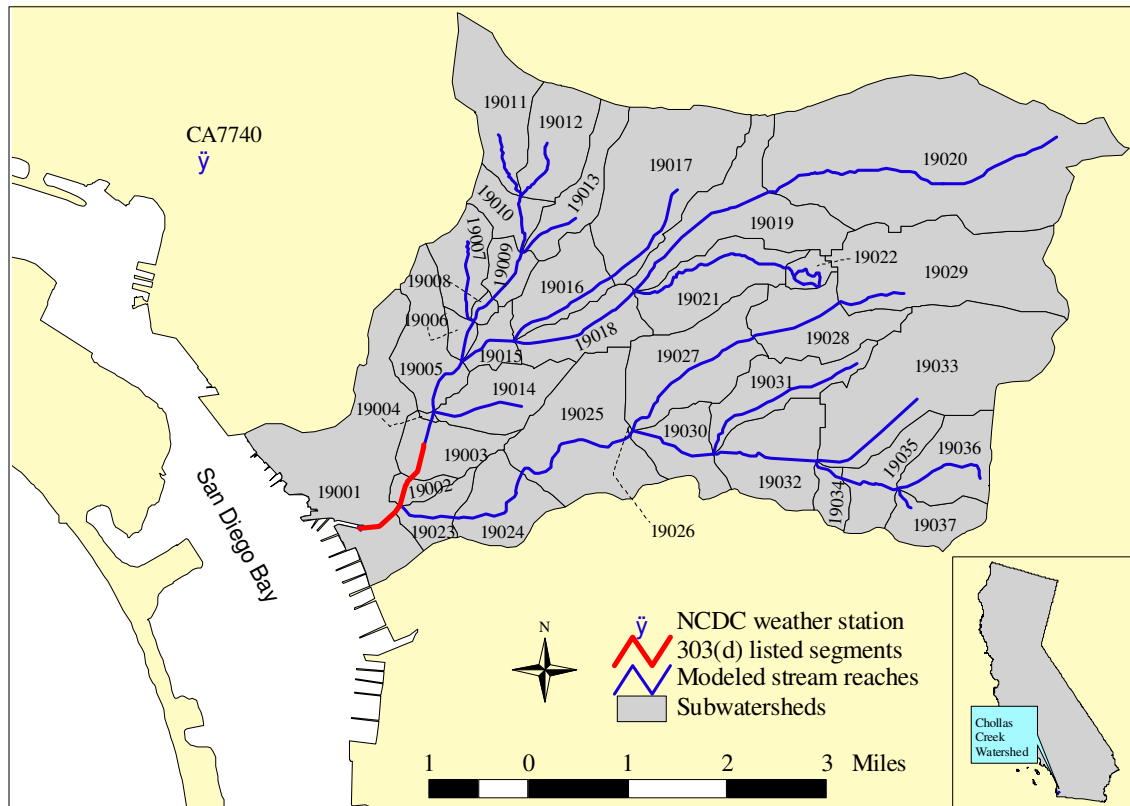


Figure 11. The Chollas Creek watershed. The numbers refer to the segment identifications used in the models.

The Chollas Creek watershed boundary was based primarily on the Cal Water GIS coverage. The only exception is the western-northwestern border. This border was refined from the Cal Water boundary based on the shape file provided by the Regional Board. This border was further refined using the topography lines on the USGS quadrangle maps. See Figure 12 for an illustration of the final watershed boundary, the Regional Board boundary, and the Cal Water boundary. The three boundaries overlap around the entire watershed except for the western-northwestern edge.

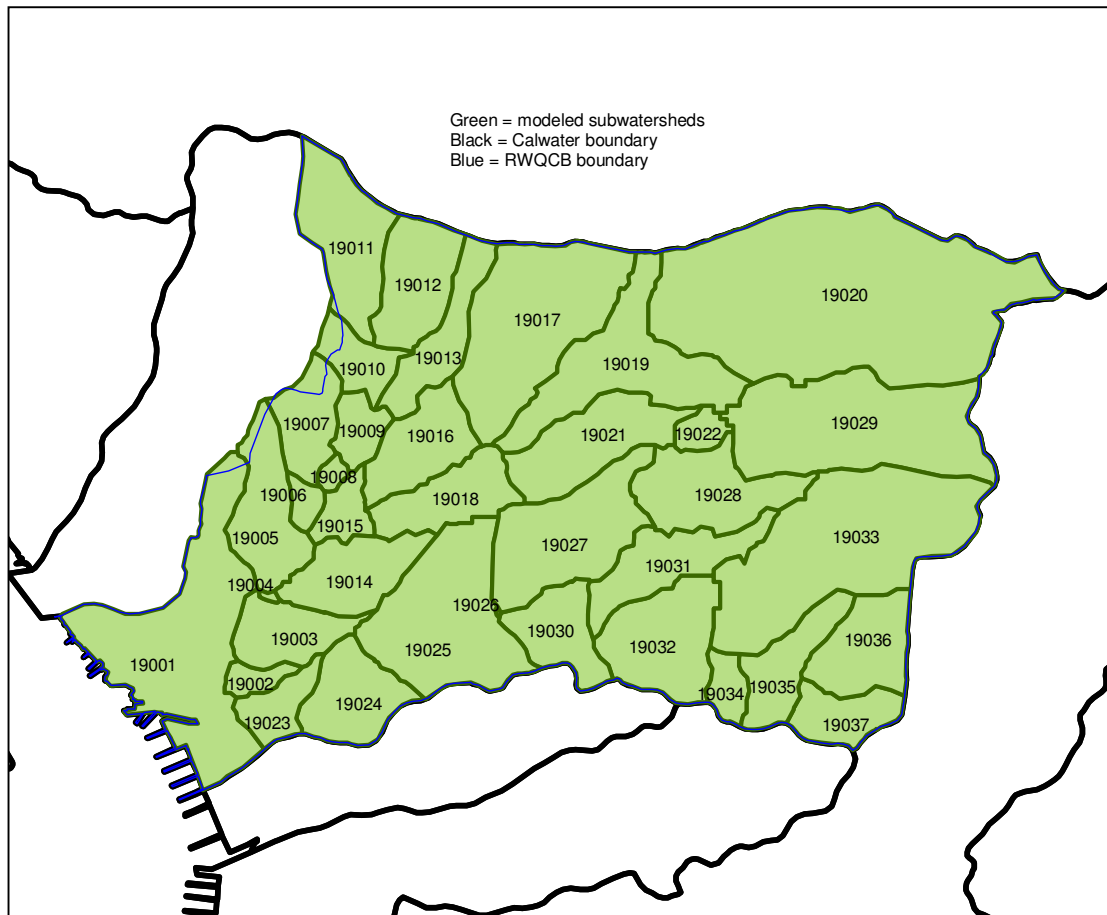


Figure 12. Three boundaries comprising the watershed boundary for Chollas Creek with model segment identification numbers.

4.2.3. Wet Weather Model Land Use Representation

The watershed model requires a basis for distributing hydrologic and pollutant loading parameters. This is necessary to appropriately represent hydrologic variability throughout the basin, which is influenced by land surface and subsurface characteristics. Representing variability in pollutant loading, which is highly correlated to land practices, also is necessary. The basis for this distribution was provided by land use coverage of the entire modeled area.

Three sources of land use data were used in the San Diego regional hydrologic model modeling effort. The primary source of data was the SANDAG 2000 land use dataset that covers San Diego County. This dataset was supplemented with land use data from the Southern California Association of Governments (SCAG) for Orange County and portions of Riverside County. A small area in Riverside County was not covered by either land use dataset. To obtain complete coverage, the 1993 USGS Multi-Resolution Land Characteristic data were used to fill this remaining data gap.

Although the multiple categories in the land use coverage provide much detail regarding spatial representation of land practices in the watershed, such resolution is unnecessary for watershed modeling if many of the categories share hydrologic or pollutant loading

characteristics. Therefore, many land use categories were grouped into similar classifications, resulting in a subset of 13 categories for the San Diego region (Tetra Tech, 2004).

For the current modeling effort, land use reclassification was also performed. SANDAG was the only source necessary for land use data in the Chollas Creek watershed. The original SANDAG land uses were grouped into categories that share hydrologic and metal loading characteristics. For example, many urban categories were represented independently (e.g., high density residential, low density residential, industrial, and commercial/ institutional) because they have different levels of impervious cover and their associated metal-contributing practices (and thus, accumulation rates) vary. During the reclassification process, land uses were kept hydrologically consistent with the land use classifications for the San Diego regional hydrologic model so that the regionally calibrated land use-specific hydrology parameters could be applied to the current modeling effort. Appendix E provides descriptions of the land uses used and the areas associated with each land use grouping for the Chollas Creek Metals TMDL project.

LSPC algorithms require that land use categories be divided into separate pervious and impervious land units for modeling. This division was made for the appropriate land uses (primarily urban) to represent impervious and pervious areas separately. The division was based on typical impervious percentages associated with different land use types from the Soil Conservation Service's TR-55 Manual (Soil Conservation Service, 1986).

In addition, soil data were obtained from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Services State Soil Geographic (STATSGO) database. Topographic data, or DEM, were obtained from USEPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) system (USEPA, 1998).

4.2.4. Wet Weather Model Meteorology

Meteorological data are a critical component of the watershed model. LSPC requires appropriate representation of precipitation and potential evapotranspiration. In general, hourly precipitation (or finer resolution) data are recommended for nonpoint source modeling. Therefore, only weather stations with hourly-recorded data were considered in the precipitation data selection process. Storm water runoff processes for each subwatershed were driven by precipitation data from the most representative station. These data provide necessary input to LSPC algorithms for hydrologic and water quality representation.

Meteorological data were accessed from a number of sources in an effort to develop the most representative dataset for the San Diego region. Hourly rainfall data were obtained from the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA), the Automatic Local Evaluation in Real Time (ALERT) Flood Warning System managed by the County of San Diego, and the California Irrigation Management Information System (CIMIS). The above data were reviewed based on geographic location, period of record, and missing data to determine the most appropriate meteorological stations. Ultimately, meteorological data were utilized from 16 area weather stations for January 1990 to September 2002 (Figure 13) for the San Diego regional hydrologic model. The spatial variability captured by these weather stations greatly

enhanced the hydrology calibration and validation and development of the regionally calibrated parameters, which were utilized for the Chollas Creek Metals TMDL project.

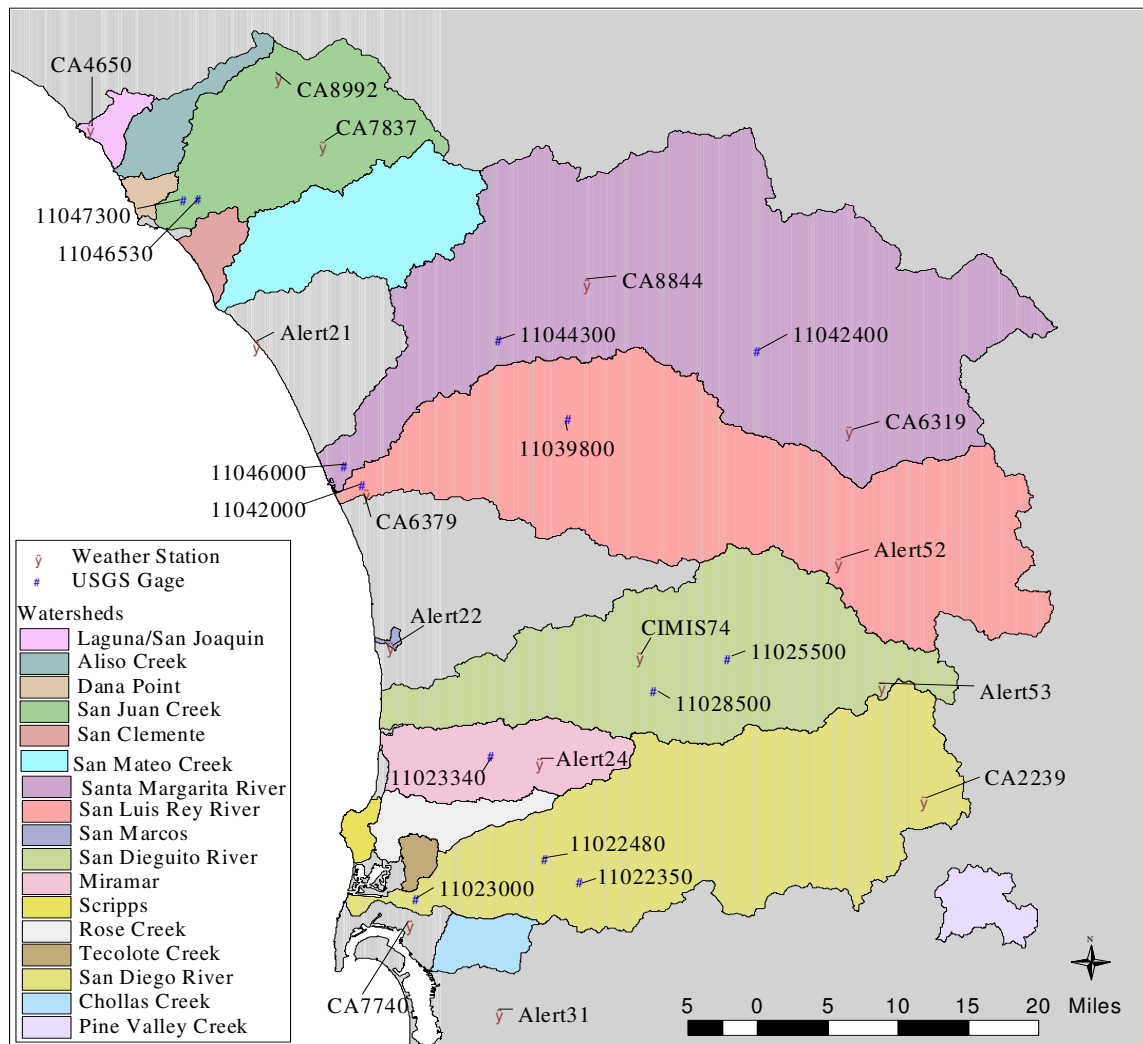


Figure 13. Weather stations and flow gages utilized for the San Diego regional hydrological model.⁴

Long-term hourly wind speed, cloud cover, temperature, and dew point data are available for a number of weather stations in the San Diego region. Data from San Diego Airport, Lindbergh Field, (#CA7740 on Figure 13) were obtained from NCDC for characterization of meteorology of the modeled watersheds. Using these data, the METCMP (Computation of Meteorological Time Series) utility, available from USGS, was employed to estimate hourly potential evapotranspiration.

Lindbergh Field is the most representative weather station for the Chollas Creek watershed with hourly data. In order to utilize the most current data possible for the Chollas Creek

⁴ Table 5 gives more information on data collected at each station.

Metals TMDL project, the period of record for Lindbergh Field meteorological data was extended through 2003.

4.2.5. Wet Weather Model Hydrology Representation

Generally, LSPC hydrologic simulations combine the observed meteorological data and the physical characteristics of the watershed. Surface runoff in a watershed was simulated in four components: surface runoff from impervious surfaces, surface runoff from pervious surfaces, interflow from pervious areas, and groundwater flow (Donigian et al., 1984). Parameter values within LSPC represented different characteristics of these components.

Here, the LSPC PWATER (water simulation for pervious land segments) and IWATER (water simulation for impervious land segments) modules, which are identical to those in HSPF, were used to represent hydrology for all pervious and impervious land units (Bicknell et al., 1996). Designation of key hydrologic parameters in the PWATER and IWATER modules of LSPC were required. As discussed previously, in order to satisfy this requirement, the regionally calibrated hydrologic parameter values from the San Diego regional hydrologic model were used. Model calibration and validation of the San Diego regional hydrologic model is discussed the next section, thus describing the applicability of these parameter values to the Chollas Creek watershed.

In some watersheds, in addition to the streams which route flow and transport pollutants through the watersheds, there are several reservoirs that are large enough to impound a significant portion of flow during wet weather periods. There is one small reservoir in the Chollas Creek watershed; however, it drains an extremely small land area and is not hydrologically connected to the main stream network in the watershed. Therefore, the Chollas Reservoir was not simulated as an impoundment in the LSPC model.

4.2.6. Wet Weather Model Metals Water Quality Representation

For the San Diego regional hydrologic modeling efforts, six major inland dischargers were incorporated into the LSPC model as point sources of flow and bacteria concentration. Each point source was located in the Santa Margarita River watershed – five at Camp Pendleton and one along Murrieta Creek (Santa Rosa Water Reclamation Facility). Although the Santa Margarita River watershed had no waterbodies impaired from bacteria loads, it was simulated in the wet weather model due to the availability of flow rates and bacteria concentration monitoring data, which were used for hydrologic and water quality calibration and validation. There are no inland dischargers impacting flow in the Chollas Creek watershed. However, discussion of the facilities in the Santa Margarita River Watershed is important because they were incorporated into the flow model calibration and validation for the San Diego regional hydrologic model, which was utilized during this current LPSC application.

Loading processes for copper, lead, and zinc loads were represented for each land unit using the LSPC PQUAL (simulation of quality constituents for pervious land segments) and IQUAL (simulation of quality constituents for impervious land segments) modules, which

are identical to those in HSPF. These modules simulate the accumulation of pollutants during dry periods and the wash-off of pollutants during storm events. Starting values for parameters relating to land use-specific accumulation rates and buildup limits, were derived from 1997 through 1999 storm water program data from the County of Los Angeles (LACDPW, 1998, 1999). These starting values served as baseline conditions for water quality calibration. Although atmospheric deposition may be an issue in the watersheds, it was not explicitly simulated in the watershed model. It was, however, represented implicitly in the model through use of the land use- and pollutant-specific accumulation rates.

4.3. Wet Weather Model Calibration and Validation

As described above, model calibration is an iterative process, because it involves the adjustment or fine-tuning of modeling parameters to reproduce observations. After modifying individual parameters, a new simulation was performed for different LSPC modules, at multiple locations throughout the San Diego region, and for the same time periods. The resultant simulated and observed stream flows were then compared. This process was repeated until the best agreement between the modeled and observed flows was achieved. This method provides the most accurate prediction possible for the hydrologic functions by ensuring that heterogeneities were represented.

Subsequently, model validation was performed to test the calibrated parameters at different locations or for different time periods, without further adjustment. Model validation consisted of re-running the model for a different date range using the same parameter values as the calibrated model. The results of this simulation were then compared to applicable observed data. This process performs a similar function to that of a control test subject, in which the model validation results indicate if selected parameter values are representative of the hydrologic functions of the watershed over time. If model validation indicates that the model results are not representative of the watershed over a certain time period, model calibration may be repeated or the model user may evaluate the watershed-specific functions responsible for the differences.

4.3.1. General Hydrologic Calibration and Validation for Wet Weather Conditions

Hydrology is the first model component calibrated because estimation of pollutant loading relies heavily on flow prediction. The hydrology calibration involves a comparison of model results to in-stream flow observations at selected locations. After comparing the results, key hydrologic parameters were adjusted and additional model simulations were performed. This iterative process was repeated until the simulated results closely represented the system and reproduced observed flow patterns and magnitudes. The last step is to validate the hydrologic model output with observed flow data.

The first step in hydrologic calibration is to establish an annual water balance between modeled and actual flow rates. The following water balance can estimate surface runoff: precipitation minus actual evapotranspiration, deep percolation, and change in soil moisture. Parameters in the PWATER and IWATER sub-modules had the greatest impact on these hydrologic functions. Specifically, LZSN, INFILT, LZETP, and DEEPFR were the key parameters that govern the water balance. (Figure 14)

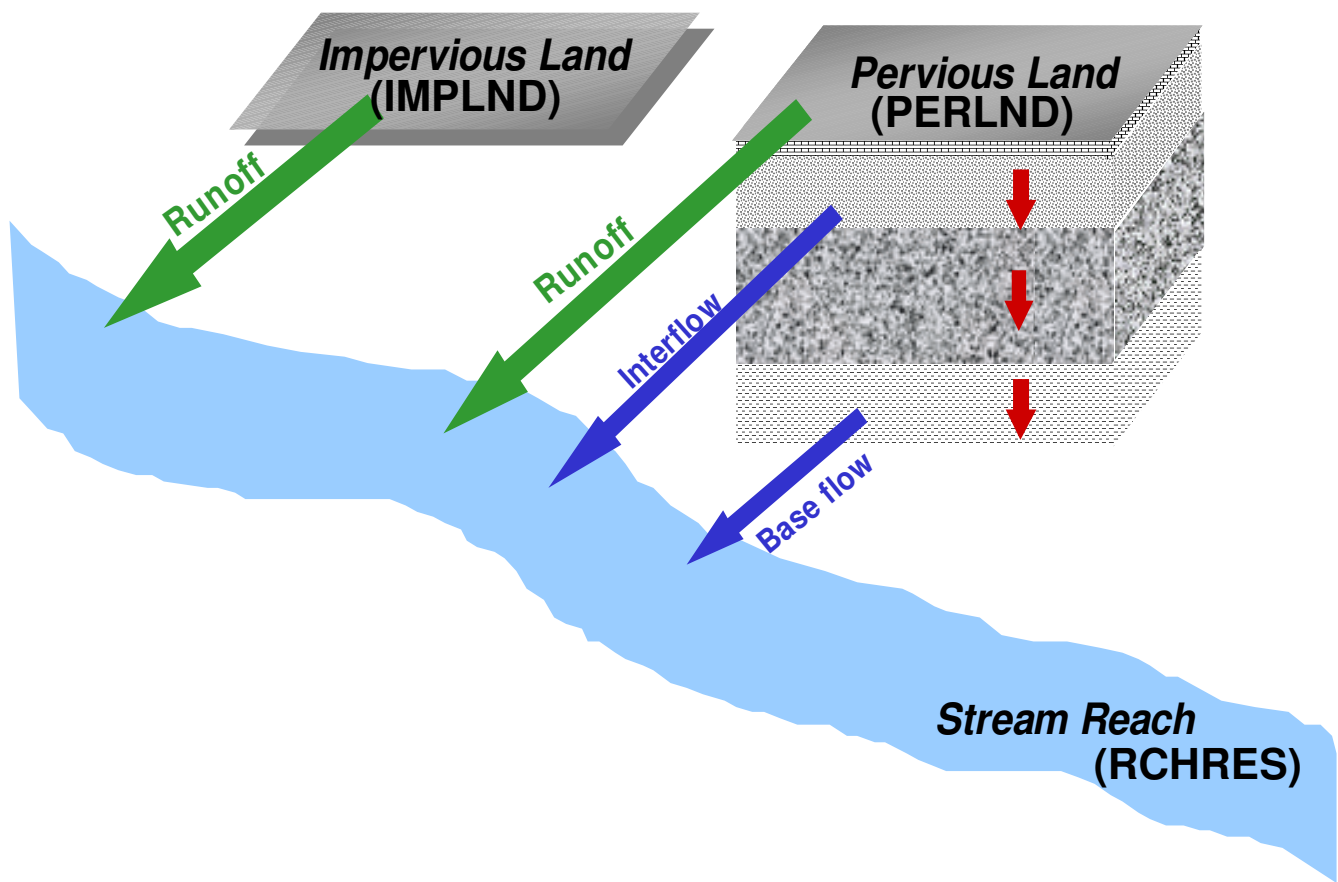


Figure 14. Physical representation of the three LSPC modules (USEPA, 1998).

The LZSN parameter is the lower zone nominal soil moisture storage. It is related to the precipitation patterns and soil characteristics in the subwatershed. Specifically, increasing LZSN will increase actual evapotranspiration, thus decreasing annual surface runoff (USEPA, 2000). The index to mean soil infiltration rate is represented by INFILT. This parameter controls the overall distribution of the available moisture from precipitation that has been intercepted into the ground. This parameter is usually utilized to represent seasonal surface runoff distributions. Increasing the value of INFILT will ultimately decrease surface runoff since it increases the transfer of water to the lower zone and groundwater. The LZETP parameter is a coefficient that represents the lower zone evapotranspiration and as values of LZETP increase, evapotranspiration increases thereby decreasing annual surface runoff. The last key parameter to effect annual water balance is DEEPFR, or the fraction of infiltrating water lost to inactive groundwater. Decreasing DEEPFR results in higher base flow and an increase in annual water balance (Donigian et al., 1984).

Subsequent to establishing an annual water balance, hydrographs for selected storm events can be adjusted to better agree with observed values. There are a variety of parameters that can be altered to effectively calibrate such hydrographs. However, continuous flow data over individual storms are necessary to create the desired hydrographs. These data were not available for The Chollas Creek watershed; therefore, stream flow calibration was limited to the annual water balance.

In addition to hydrologic calibration of the surface water, performed by adjusting parameters in the PWATER and IWATER sub-modules, hydraulic calibration was conducted using the RCHRES sub-module. The overall flows simulated in the RCHRES sub-module are a result of the overland hydrology from pervious and impervious lands and the stream characteristics contained in the hydrologic function tables (Donigian et al., 1984).

The rest of this discussion is divided into two sections: one on regional hydrological simulations and one on the application of these regional hydrology simulations to the Chollas Creek watershed. The hydrology simulations conducted for the San Diego region resulted in a regionally calibrated set of parameter values. These parameters were applied to the Chollas Creek watershed in order to make flow predictions.

4.3.2. Wet Weather Model Use of the San Diego Region Hydrologic Model

Gaging stations representing diverse hydrologic regions of the San Diego region were used for calibration, including eleven USGS flow gage stations (Table 5 and Figure 13). These gaging stations were selected because they either had a robust historical record or they were in a strategic location (i.e. along a listed water quality limited segment, downstream of a reservoir, or along an otherwise unmonitored reach).

Table 5. USGS Stations Used For Hydrology Calibration and Validation

Station	Station Name	Historical Record	Selected	Selected	Watershed
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Chollas Creek Metals TMDL

Appendix D

Page

Number			Calibration Period	Validation Period	and Model Subwatershed
11022480	San Diego River at Mast Road near Santee, CA	5/1/1912 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Diego River (1805)
11023000	San Diego River at Fashion Valley at San Diego, CA	1/18/1982 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Diego River (1801)
11023340	Los Penasquitos Creek near Poway, CA	10/1/1964 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	Miramar (1406)
11025500	Santa Ysabel Creek near Ramona, CA	2/1/1912 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Dieguito (1316)
11028500	Santa Maria Creek near Ramona, CA	12/1/1912 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Dieguito (1324)
11042000	San Luis Rey River at Oceanside, CA	10/1/1912 - 11/10/1997; 4/29/1998 - 9/30/2002	9/1/1993 - 8/31/1997	5/1/1998 - 4/30/2002	San Luis Rey (702)
11042400	Temecula Creek near Aguanga, CA	8/1/1957 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	Santa Margarita (658)
11044300	Santa Margarita River at FPUD Sump near Fallbrook, CA	10/1/1989 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	Santa Margarita (615)
11046000	Santa Margarita River at Ysidora, CA	3/1/1923 - 2/25/1999; 10/1/2001 - 9/30/2002	1/1/1991 - 12/31/1995	1/1/1996 - 12/31/1998	Santa Margarita (602)
11046530	San Juan Creek at La Novia Street Bridge near San Juan Capistrano, CA	10/1/1985 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Juan (411)
11047300	Arroyo Trabuco near San Juan Capistrano, CA	10/1/1970 - 9/30/1989; 10/1/1995 - 9/30/2002	10/1/1995 - 4/30/1999	5/1/1999 - 4/30/2002	San Juan (403)
11022350	Forester Creek near El Cajon, CA	10/1/1993 - 9/30/2002	none (insufficient period of record)	1/1/1991 - 9/30/1993	San Diego River (1843)
11039800	San Luis Rey River at Couser Canyon Bridge near Pala, CA	10/1/1986 - 1/4/1993	none (insufficient period of record)	1/1/1991 - 12/31/1992	San Luis Rey (711)

January 1991 through September 2002 was selected as the time period for the regional simulation.⁵ The calibration years were selected based on annual precipitation variability and the availability of observation data to represent a continuum of hydrologic conditions: low, mean, and high flow. Calibration for these conditions was necessary to ensure that the model would accurately predict a range of conditions over a longer period of time.

⁵ The range was expanded for the Chollas Creek metals TMDL (January 1991 through December 2003) because newer meteorological data was available at the time of simulation.

Key considerations in the hydrology calibration included the overall water balance, the high-flow/low-flow distribution, storm-flows, and seasonal variation. At least two criteria for goodness of fit were used for calibration: graphical comparison and the relative error method. Graphical comparisons were extremely useful for judging the results of model calibration; time-variable plots of observed versus modeled flow provided insight into the model's representation of storm hydrographs, base flow recession, time distributions, and other pertinent factors often overlooked by statistical comparisons. The model's accuracy was primarily assessed through interpretation of the time-variable plots. The relative error method was used to support the goodness of fit evaluation through a quantitative comparison.

After calibrating hydrology at the eleven locations, a validation of these hydrologic parameters was made through a comparison of model output to different time periods at the same gages as well as two additional gages (Table 1). The validation essentially confirmed the applicability of the regional hydrologic parameters derived during the calibration process. Validation results were assessed similar to calibration: via graphical comparison and the relative error method.

Hydrology calibration and validation results, including time series plots and relative error tables, are presented for each gage in Appendix E of the draft TMDL report for bacteria impairment in the San Diego region (Tetra Tech, Inc., 2004). The calibration results, which are presented first, include graphs to represent overall model fit, seasonal trends, and two time series plots. A table that quantifies the model results and observed gage data follows these graphs. This table also provides relative errors between the modeled and observed values in the storm volumes and highest flows. The presentation of model validation results follows the calibration tables and graphs for each gage. Two additional gages that had a relatively less historical record were used as additional validation. Validation was assessed through a time series plot and a relative error table identical to the calibration table.

To ensure that the watershed delineation and land use reclassification processes performed for the Chollas Creek watershed did not significantly alter the predicted hydrology, the current model output was compared with the regional model output specifically for the Chollas Creek watershed. Although the Chollas Creek watershed does not have a stream gage collecting daily flow data, data were available for a series of storms (or for a period of time during a storm season) between 2001 and 2003.

4.3.3. Metal Concentration Calibration and Validation for the Chollas Creek Watershed

Once the stream flow was calibrated and validated, other hydrologically-dependent functions, including metal concentration, were simulated in order to calibrate the remaining model parameters. Regionally calibrated land use-specific accumulation and maximum build up rates for metals are not available in Southern California;⁶ therefore, a more traditional water quality calibration and validation process was performed. In addition, observed water quality

⁶ Ideally these rates would be available and could be used with water quality simulations to further validate their accuracy

data, unlike stream flow data, are usually not continuous; thus making time-series comparisons difficult and reducing the accuracy of the water quality model calibration.

The available wet weather metal concentration data (Appendix A) was separated into calibration and validation groups based on sampling stations. Station SD(8)-1 was used for calibration, because it had the most data (approximately 35 metal concentrations). Because the rest of the water quality monitoring stations had only three to five metal concentration data points, the remaining data were separated into two groups with similar spatial representation of land uses and of watersheds (Figure 15).

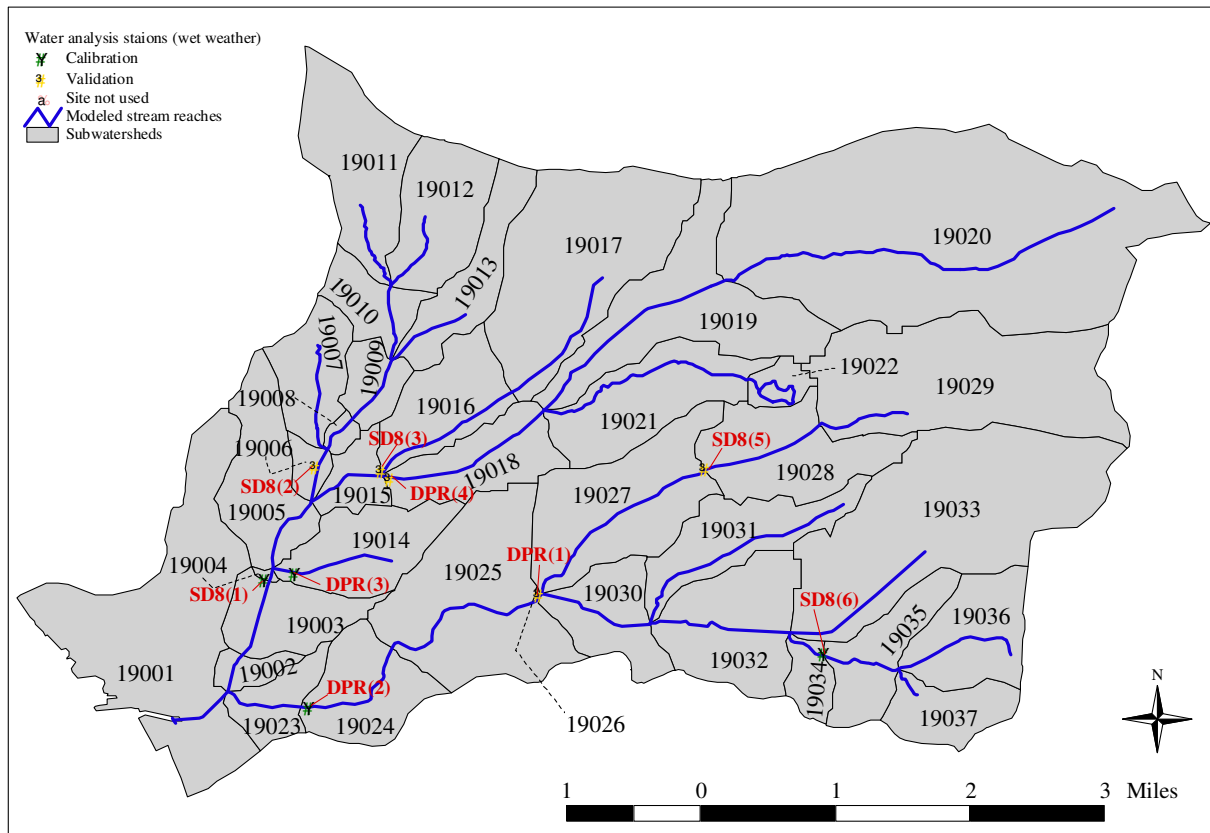


Figure 15. Map of monitoring locations used for model calibration and validation of the wet weather model.

After the appropriate calibration and validation groups were defined, the starting values for parameters relating to land use-specific accumulation rates (ACQOP) and buildup limits (SQOLIM) were defined. Their values were input for each stream reach and land use in the surrounding subwatershed. The ACQOP parameter is the daily pollutant accumulation rate. Based on this value, the concentration of a constituent accumulates until it reaches the maximum storage level, represented by SQOLIM. Additionally, the WSQOP⁷ parameter is the rate of surface runoff that will remove 90 percent of the stored constituent per hour. This parameter, along with the modeled surface runoff, controls the overall pollutant loading to

⁷ WQSOP is the rate of surface runoff that results in 90 percent wash off of fecal coliform bacteria in one hour (in/hr).

the stream (Bicknell, Imhoff, Kittle, Donigian, & Johanson, 1996). The initial accumulation rates used for this model were derived from land use specific metals data collected for the County of Los Angeles storm water program (LACDPW, 1998, 1999). Initial maximum build up rates were obtained from literature values (Butcher, 2003). These starting values served as initial conditions for water quality calibration.

Once model setup was complete, baseline simulations were performed. After entering the accumulation rate and wash-off data for each stream reach and its associated land uses, simulations were performed during time periods that overlapped the hydrology simulations. The modeled results were then compared with observed concentration data for copper, lead, and zinc. To assess model fit with available data, the time series model output was statistically and graphically compared to the observed data. Similar to the hydrology calibration process, the key parameter values (ACQOP and SQOLIM) were adjusted based on these differences and the simulations were performed again.

Once the water quality model calibration was complete, model validation was performed. This process is identical to the model validation procedures described above for hydrology validation. Namely, the model was run again using the calibrated parameter values for different monitoring locations. The results of this simulation were then compared to applicable observed metal concentration data to determine the predictive value of the model. Depending on the results of the water quality validation, the model can be considered complete, or model calibration may be repeated. (Figure 9)

4.4. Summary of Wet Weather Model Calibration and Validation

The observed flow hydrographs were on a sub-hourly time scale; however, the simulations were performed at an hourly timescale. For a comparison of the modeled and observed results, the data were summarized into average daily values and general statistical comparisons were made between the two sets of values (Appendix F). Because of the differences in time scale, the comparison is not entirely accurate.

4.4.1. Wet Weather Model Flow Rate Results

Overall, during calibration, the model predicted increased flow rates during dates when storm events had occurred. This is because the wet weather condition and surface runoff flow rate are dependent on rainfall. Occasional storms were over-predicted or under-predicted depending on the spatiality of the meteorologic and gage stations compared to the location of storms that did not cover the entire Chollas Creek watershed. The validation results also showed a good fit between modeled flow rates and observed flow rates, thus confirming the applicability of the calibrated hydrologic parameters to the San Diego region.

Minor differences were observed (the current model predicted flows approximately 8 percent higher than those from the San Diego regional hydrologic model) which resulted from the changes to the stream network and subwatershed boundaries in the current application. Specifically for the Chollas Creek Metals TMDL project, the total stream lengths increased while the total watershed area was nearly the same. This resulted in less opportunity for infiltration, because as water passed over the land surface it had to travel a shorter distance to Chollas Creek Metals TMDL

reach a stream than it did in the simulation initially ran for the San Diego region hydrologic model (i.e. overland flow was reduced). This small difference between the hydrology results was considered acceptable, especially when compared to the significant benefit of using the more detailed stream network for the Chollas Creek Metals TMDL project.

Figure 16 compares the predicted flow with these average daily observed flows. Model predictions generally fell within the range of observed data; however, some peaks were observed that were not predicted by the model. These differences are likely due to localized storms that impacted the Chollas Creek watershed, but were not detected at the modeled weather station, Lindbergh Field. In addition, the shortest time step simulated was one hour, while the observed data were on a five or fifteen minute time step. The model output and observed data were both summarized to obtain average daily flow for comparative purposes. Therefore, the storm hydrographs, including maximum storm peaks, are not represented in Figure 16. Because modeled and observed flow ranges are similar, the LSPC hydrology model flow rate results were considered representative of flow in the Chollas Creek watershed. Differences can be explained by localized events, and until additional flow data become available, further calibration is not possible, nor warranted.

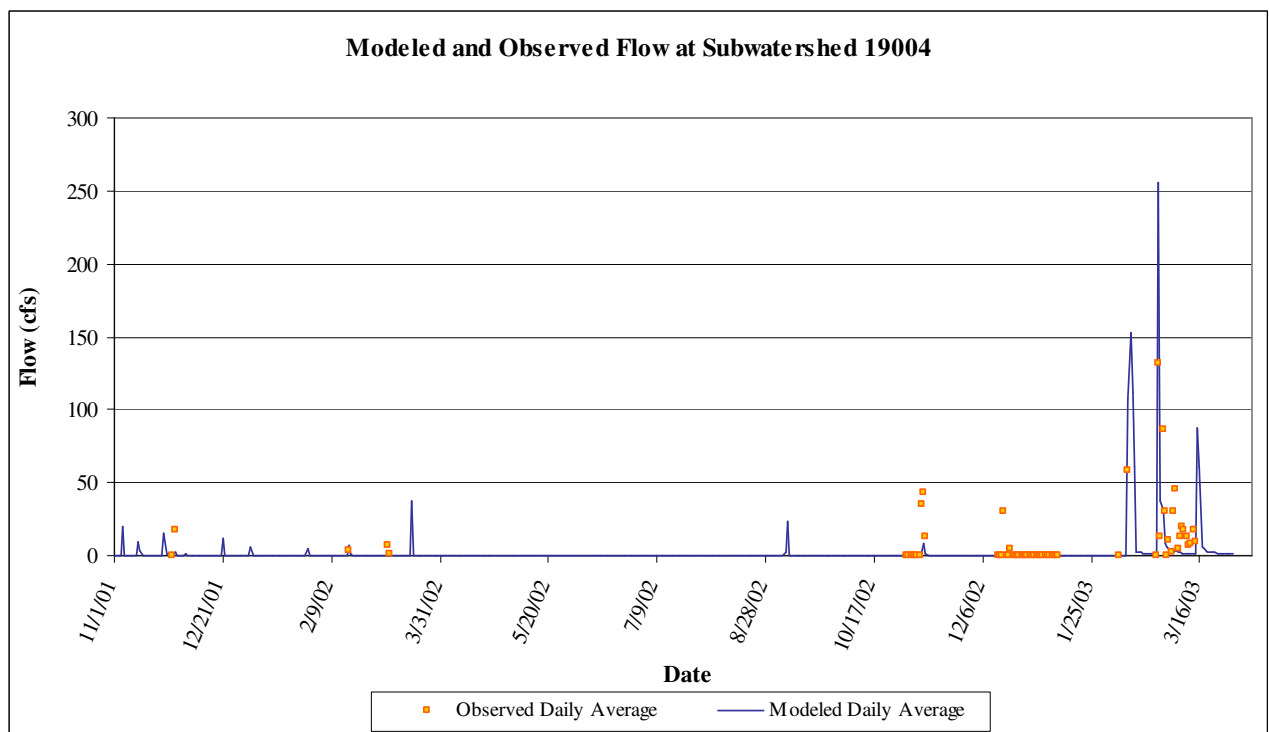


Figure 16. Modeled and observed flow at the Chollas Creek watershed Mass Loading Station

4.4.2. Wet Weather Model Metal Concentration Results

Figures 17, 19, 21, and 23 present time series graphs of modeled and observed data for the calibrated subwatersheds. Figures 18, 20, 22, and 24 are box plot graphs showing the minimum, mean, and maximum modeled values for the dates with corresponding observed data. These plots indicate that the model predicts copper, lead, and zinc concentrations well within the range of observed data and following similar patterns and magnitudes. This is especially evident in subwatersheds where there are data across a wide temporal range (Figures 17 and 18).

Using the same parameter values, model simulations were performed for validation of the calibrated parameters. Figures 25 through 34 present time series graphs and box plots for the validation subwatersheds. These results confirm the previous conclusion that the model closely predicts the observed data for copper, lead, and zinc concentrations.

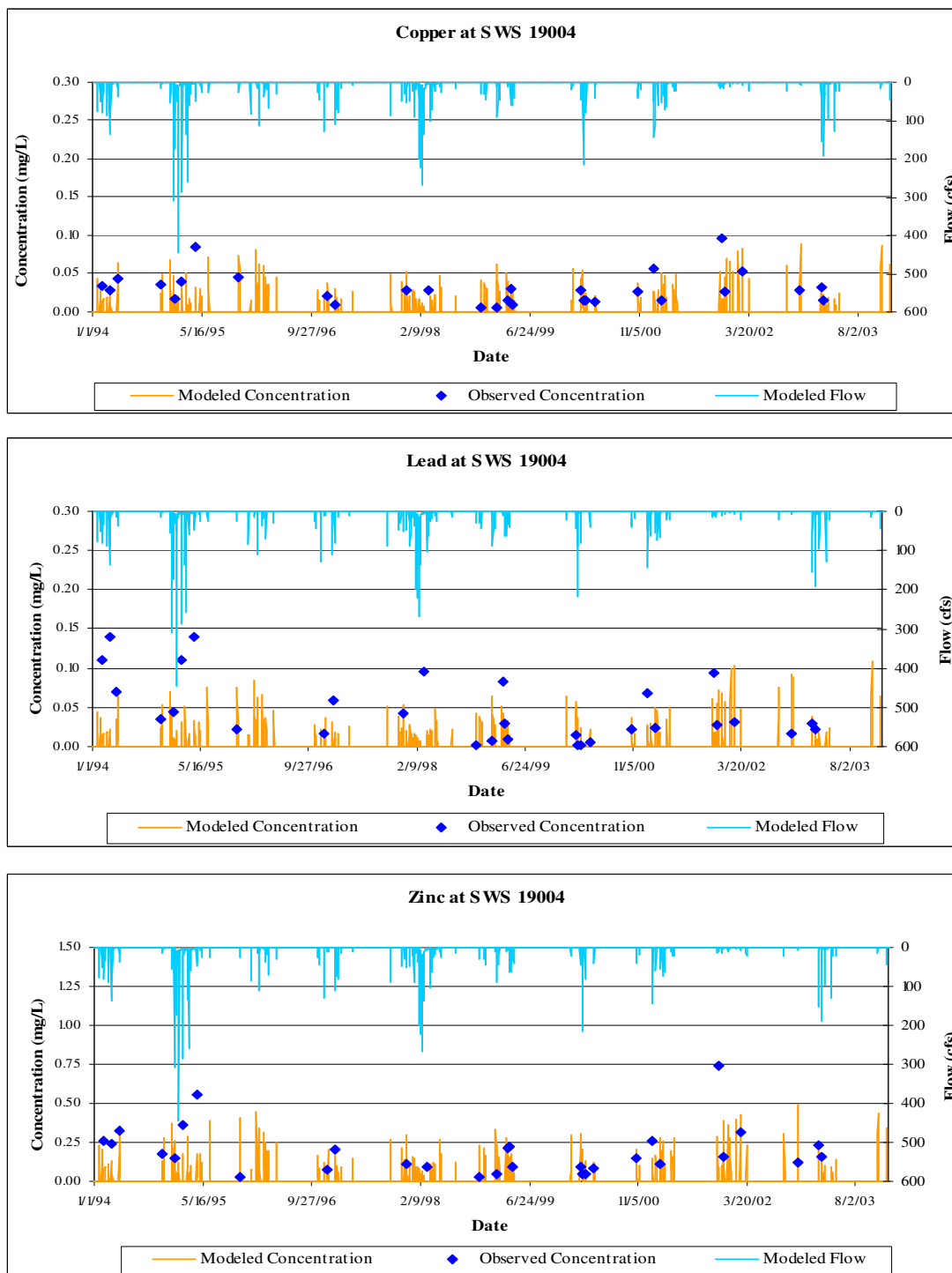


Figure 17. Time-series comparison of modeled and observed wet weather metals concentrations at sampling location SD8(1) (model calibration)

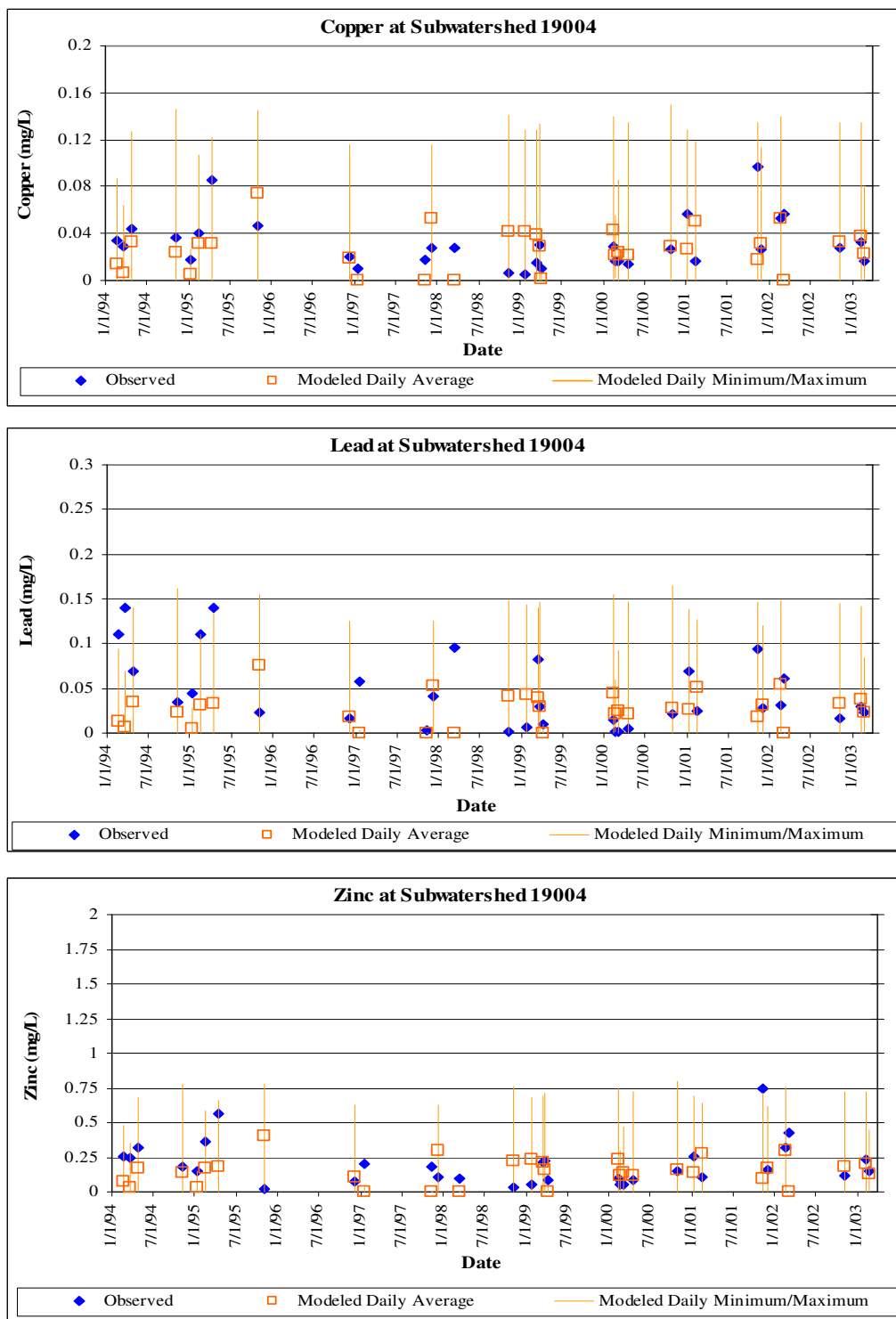


Figure 18. LSPC model results and corresponding observed metals data at sampling location SD8(1) (model calibration)

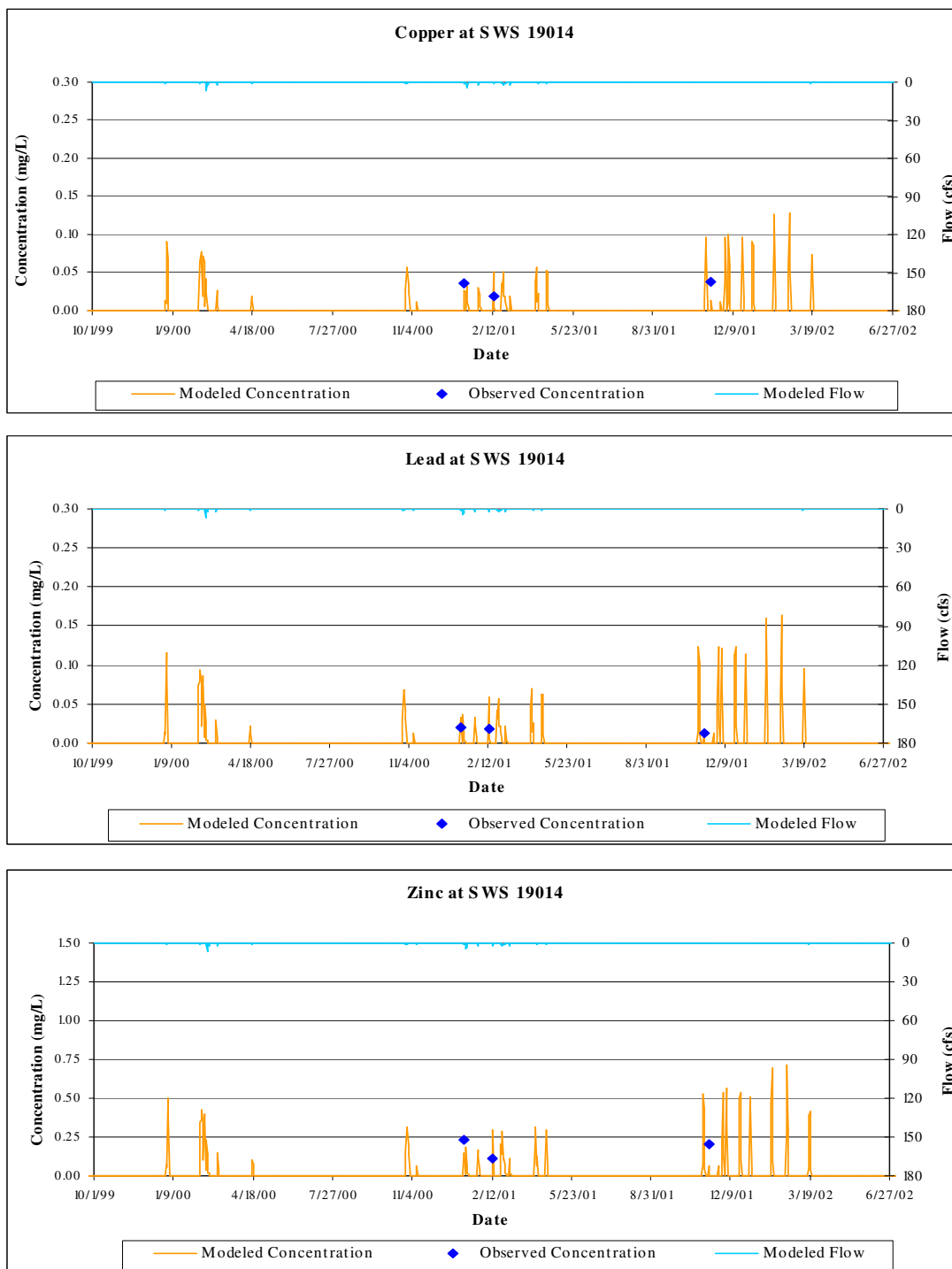


Figure 19. Time-series comparison of modeled and observed wet weather metals concentrations at sampling location DPR(3) (model calibration).

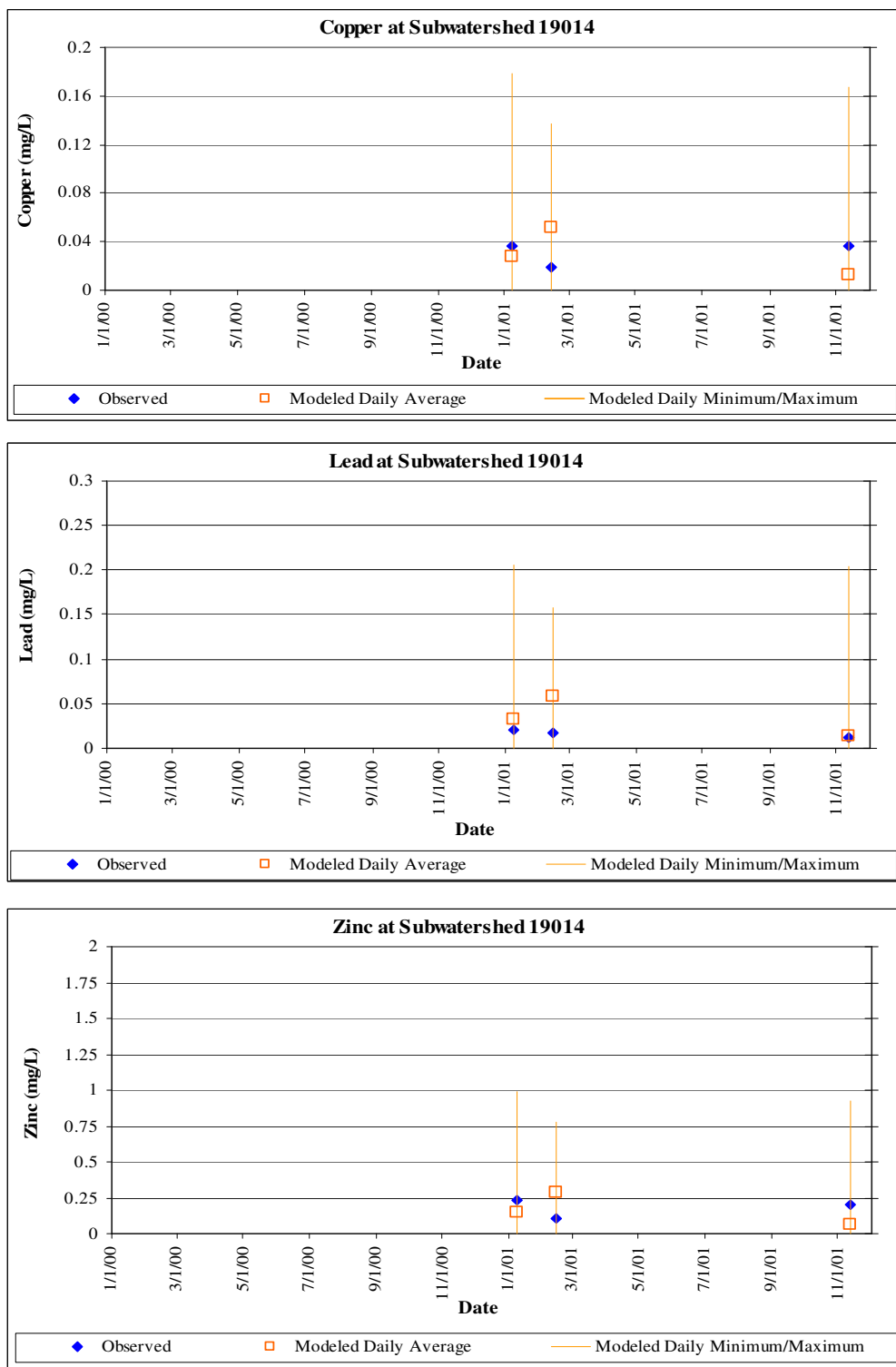


Figure 20. LSPC model results and corresponding observed metals data at sampling location DPR(3) (model calibration)

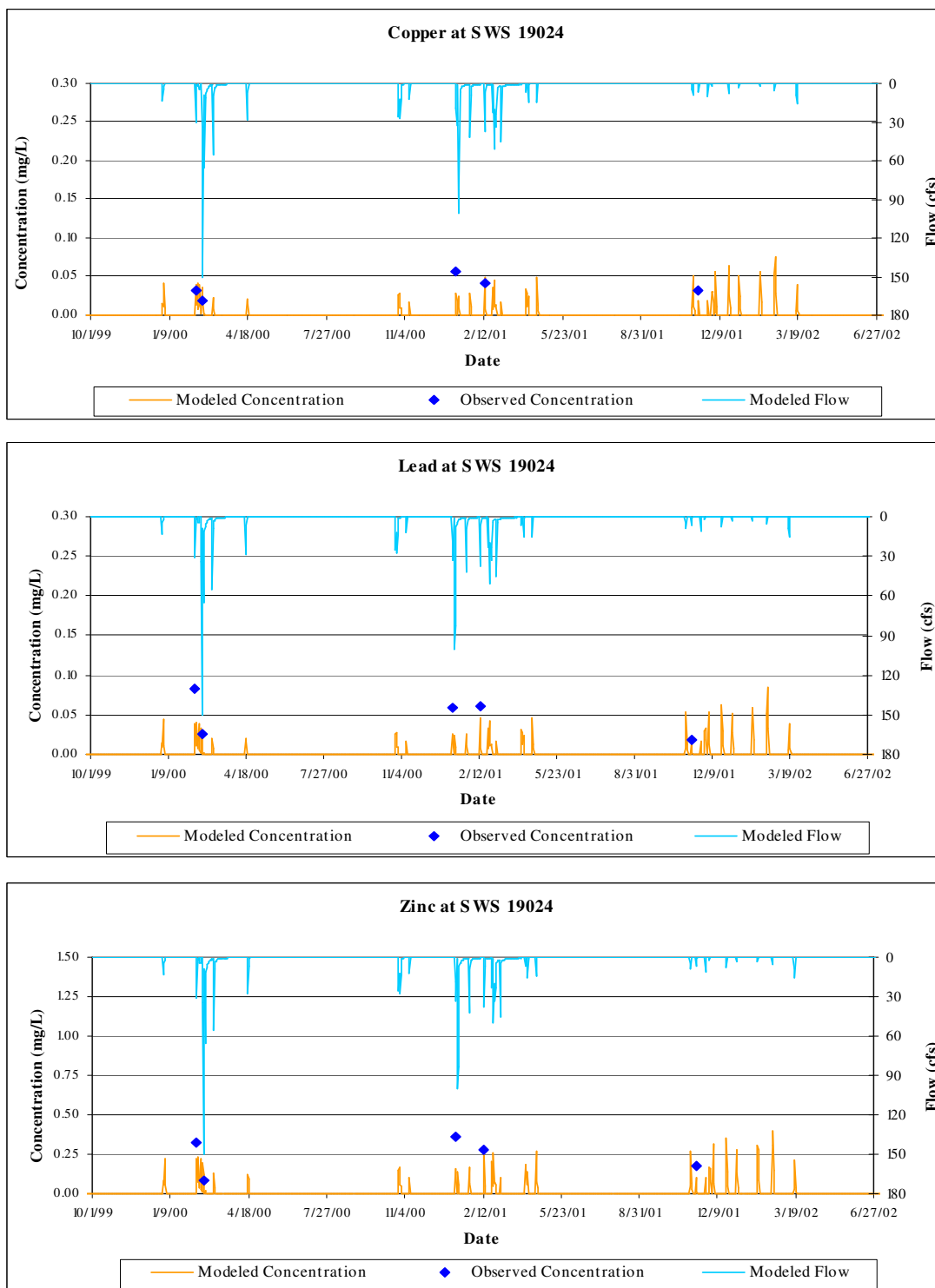


Figure 21. Time-series comparison of modeled and observed wet weather metals concentrations at sampling location DPR(2) (model calibration)

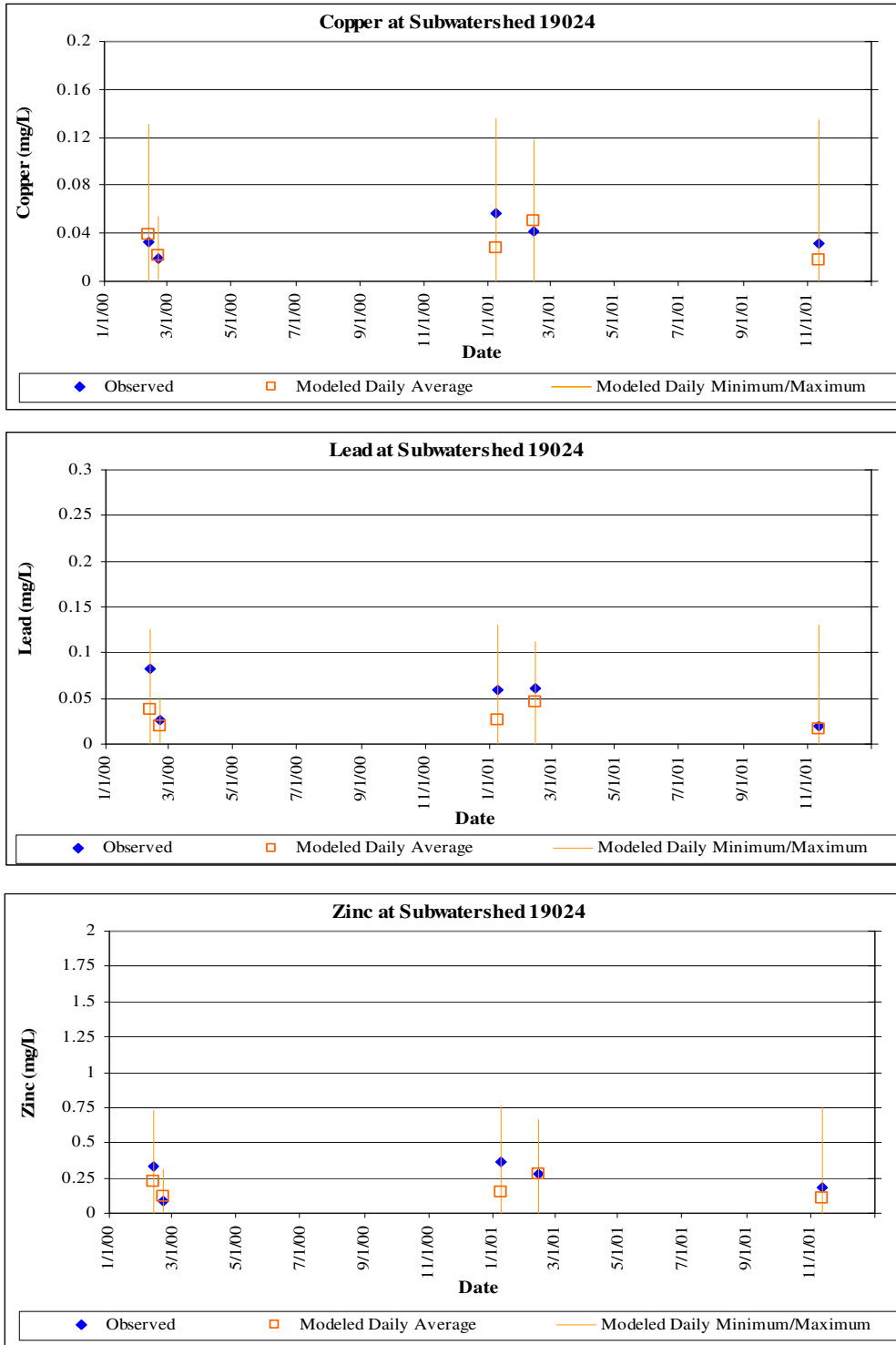


Figure 22. LSPC model results and corresponding observed metals data at sampling location DPR(2) (model calibration)

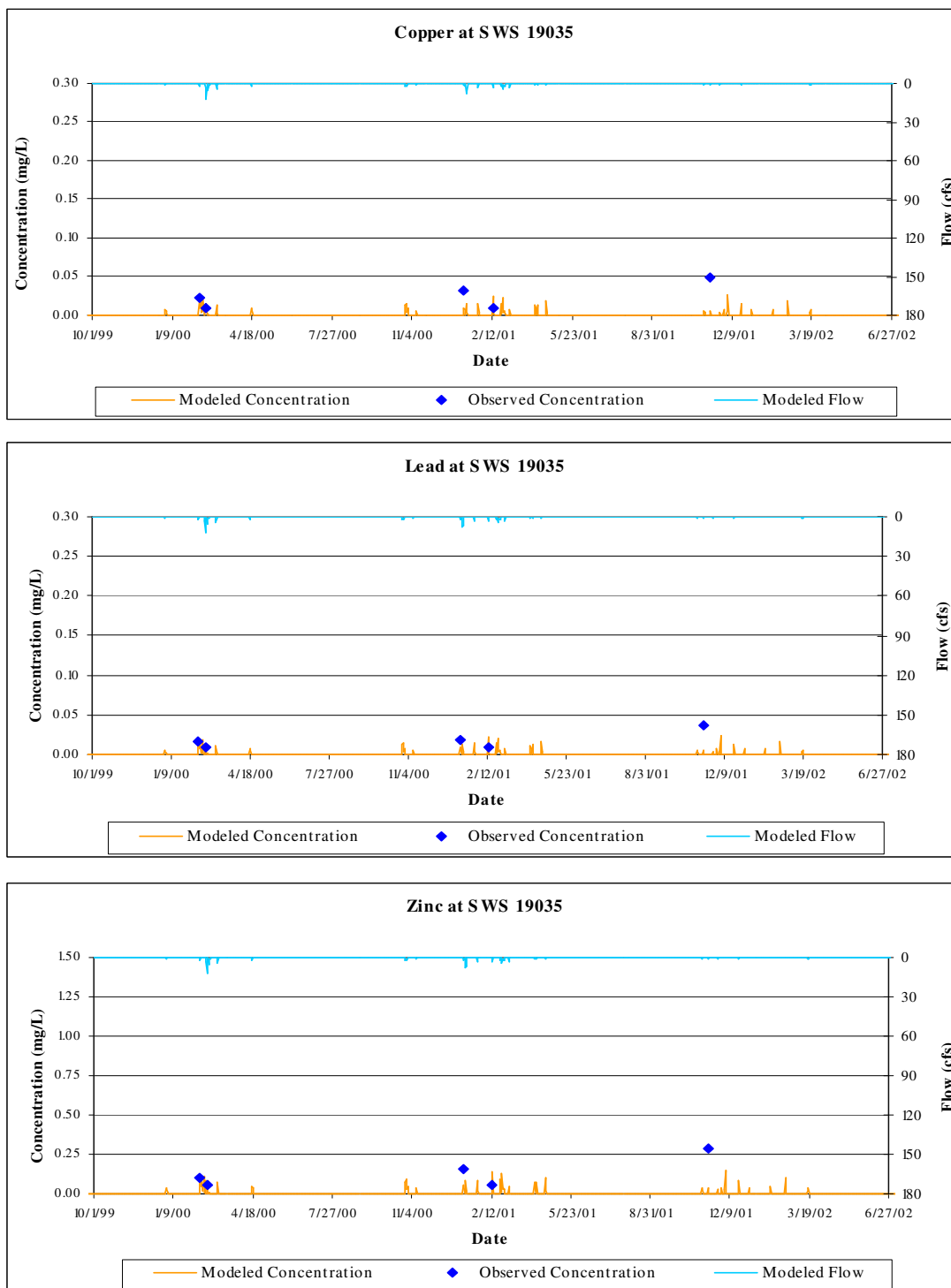


Figure 23. Time-series comparison of modeled and observed wet weather metals concentrations at sampling location SD8(6) (model calibration)

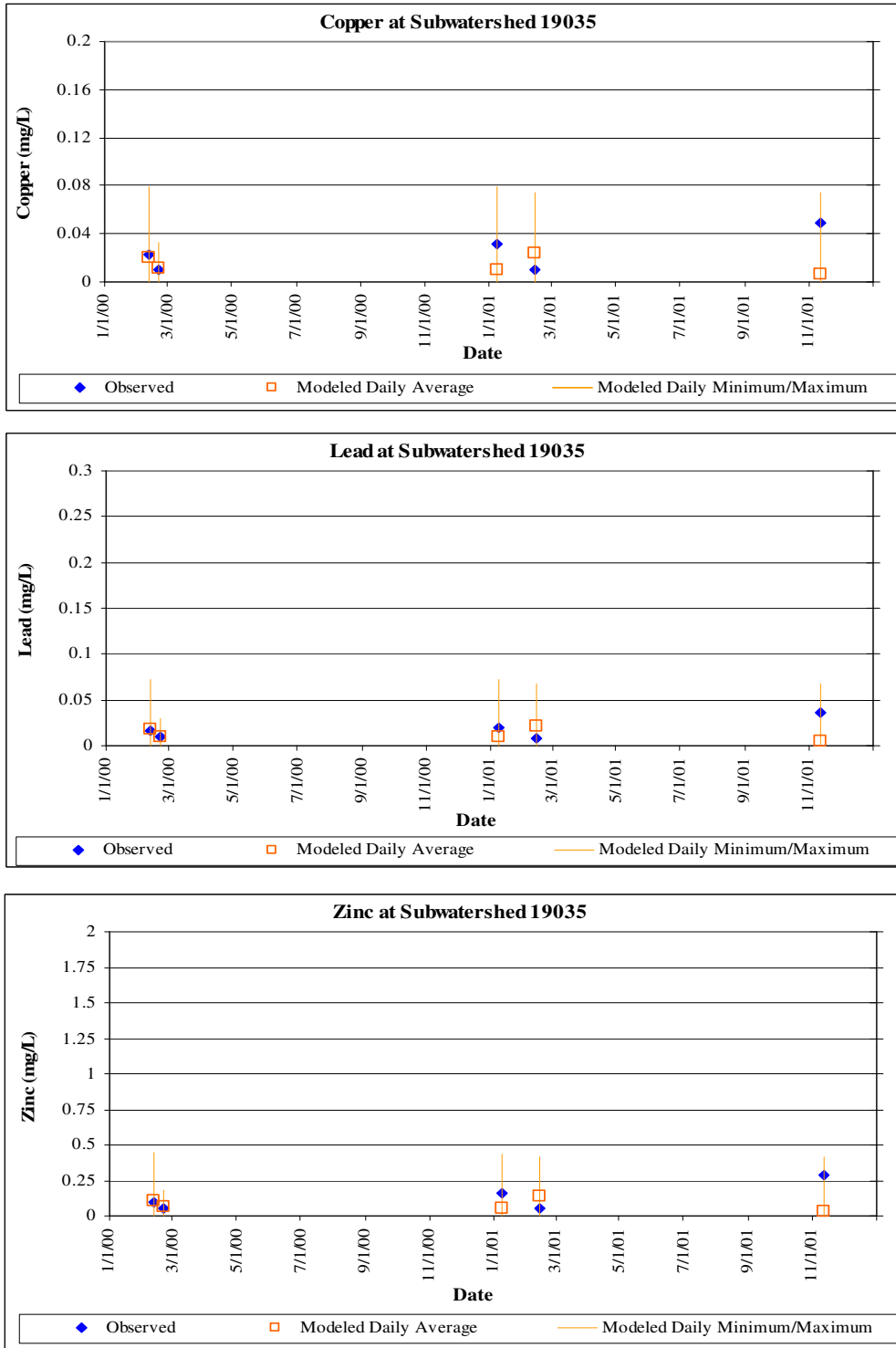


Figure 24. LSPC model results and corresponding observed metals data at sampling location SD8(6) (model calibration)

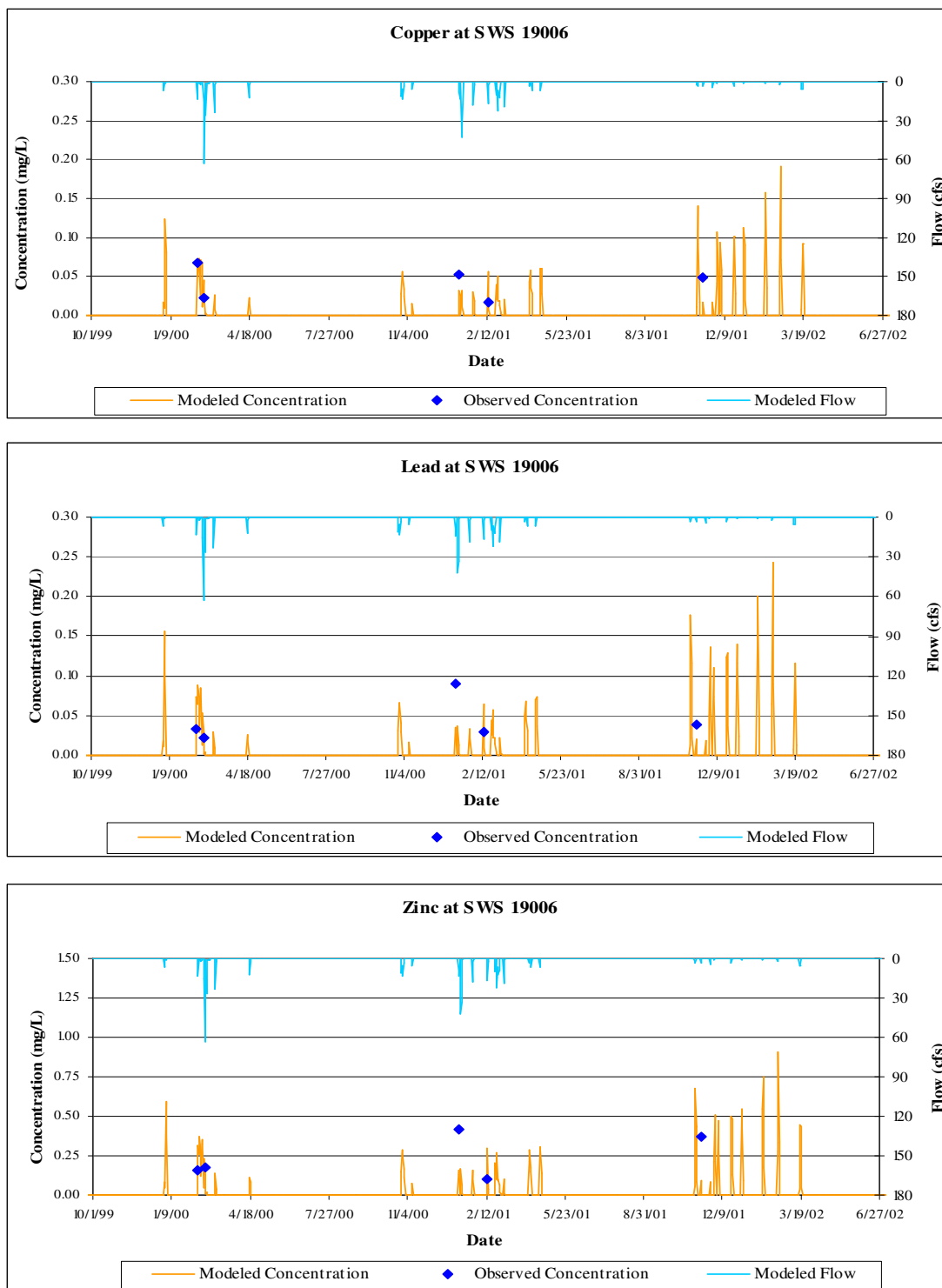


Figure 25. Time-series comparison of modeled and observed wet weather metals concentrations at sampling location SD8(2) (model validation)

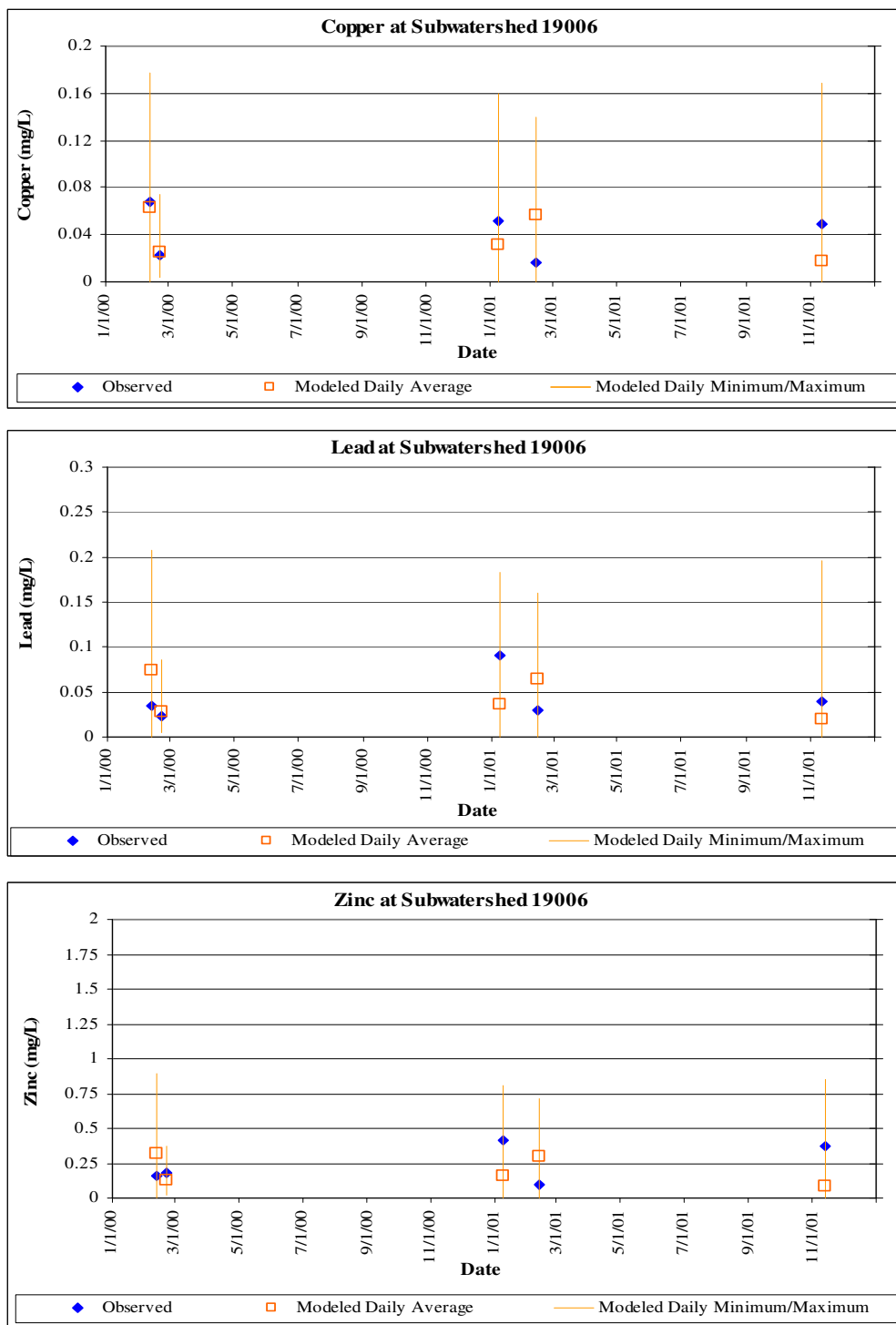


Figure 26. LSPC model results and corresponding observed metals data at sampling location SD8(2) (model validation)

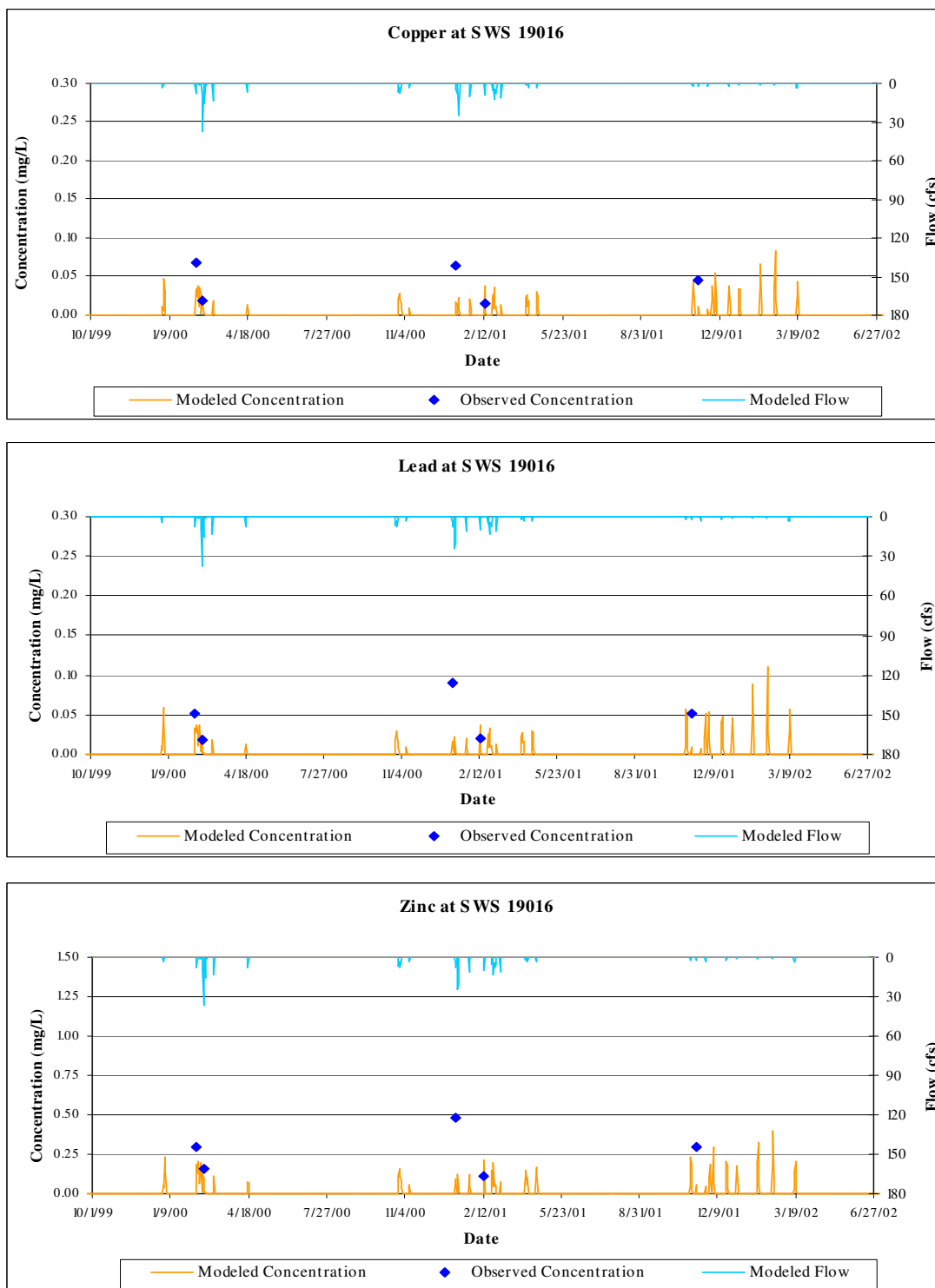


Figure 27. Time-series comparison of modeled and observed wet weather metals concentrations at sampling location SD8(3) (model validation)

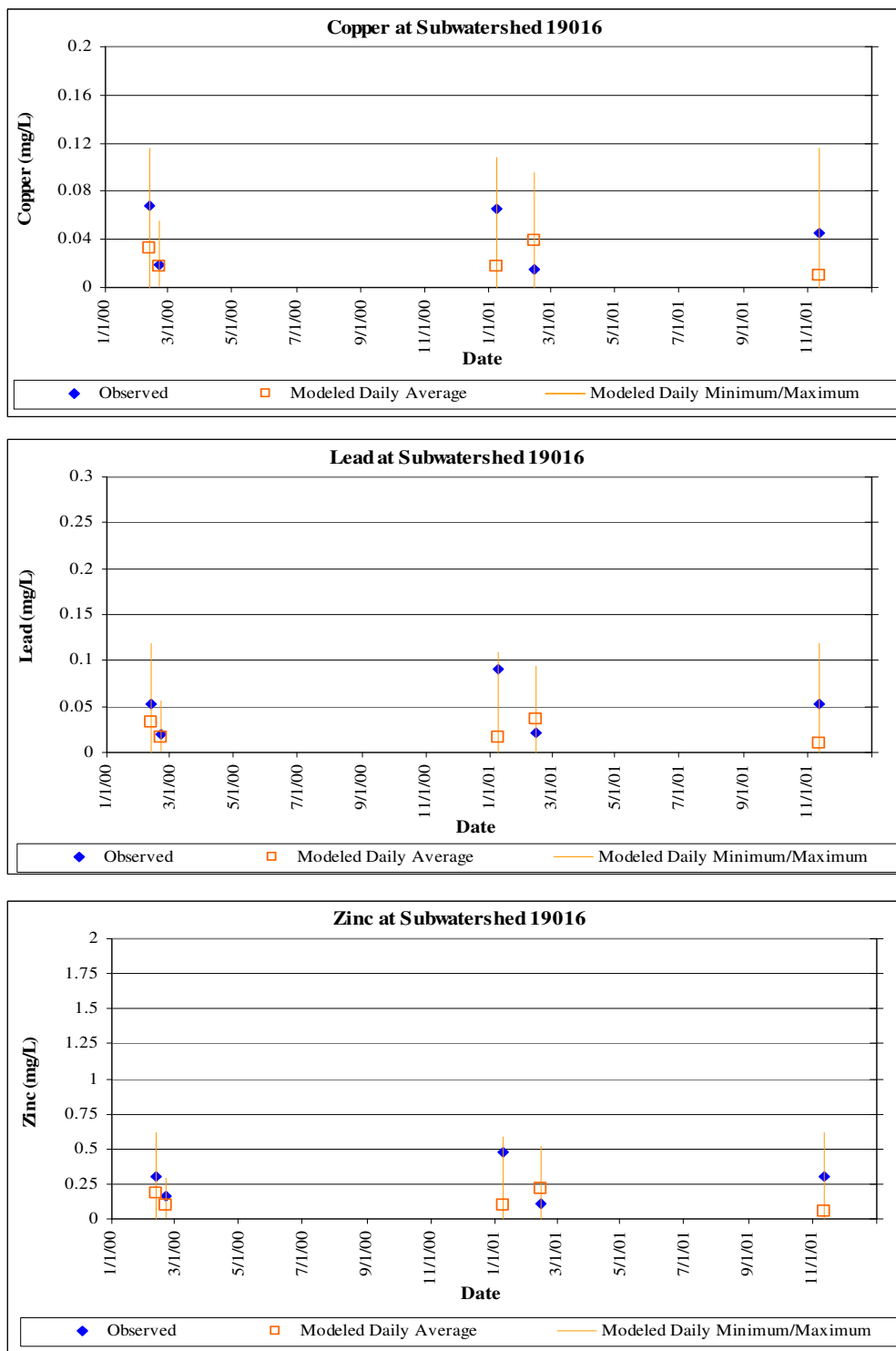


Figure 28. LSPC model results and corresponding observed metals data at sampling location SD8(3) (model validation)

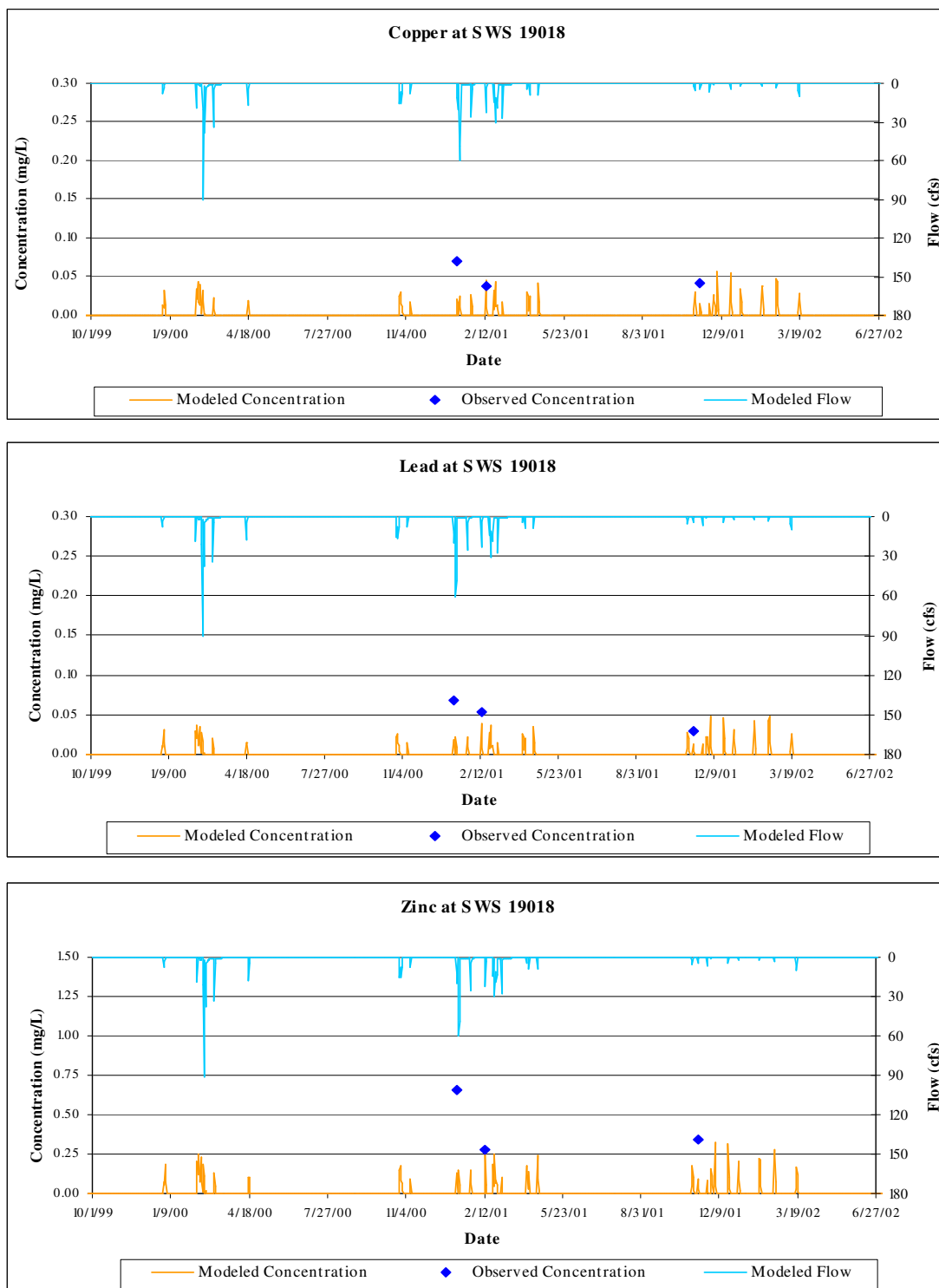


Figure 29. Time-series comparison of modeled and observed wet weather metals concentrations at sampling location DPR(4) (model validation)

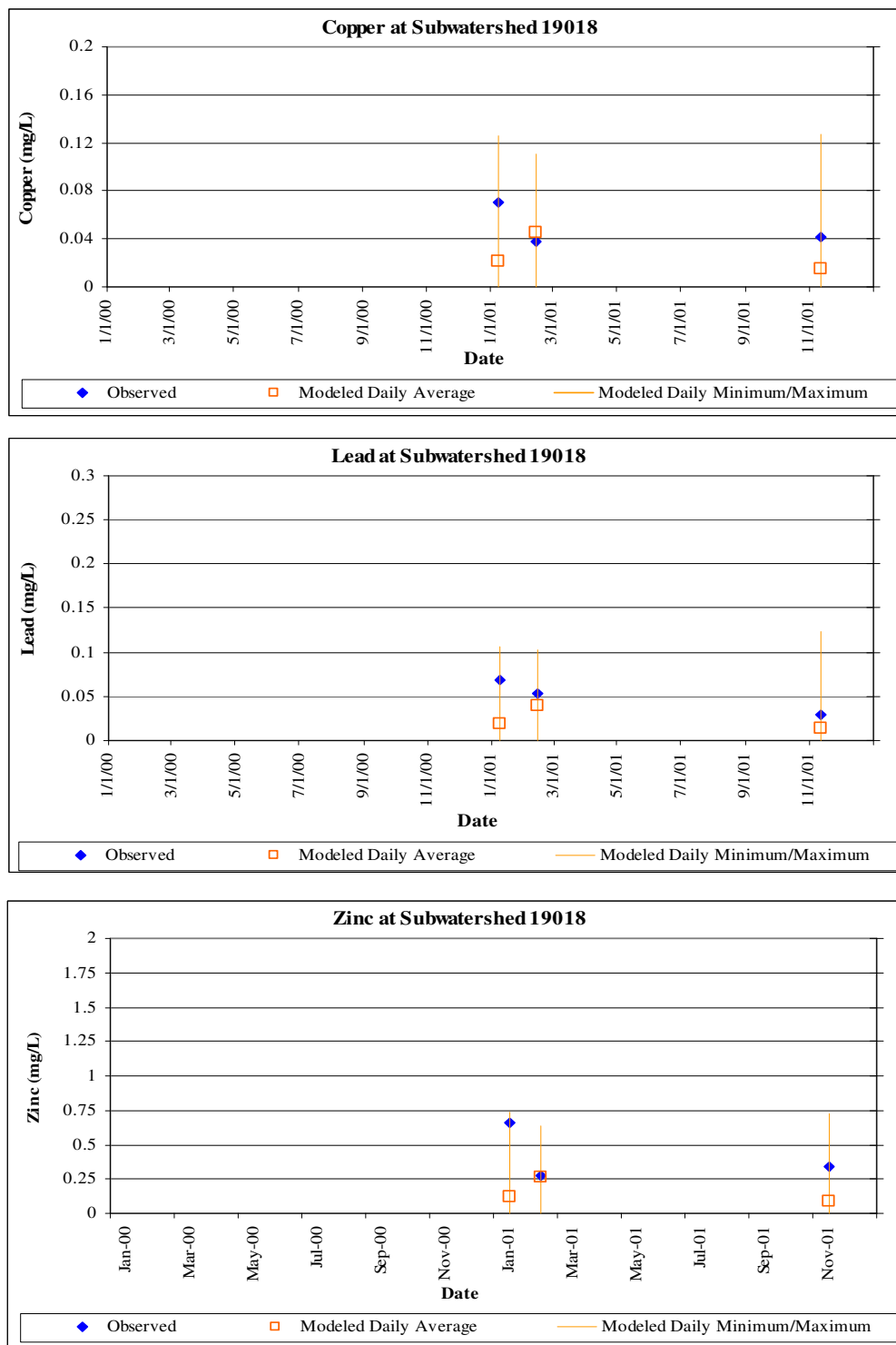


Figure 30. LSPC model results and corresponding observed metals data at sampling location DPR(4) (model validation)

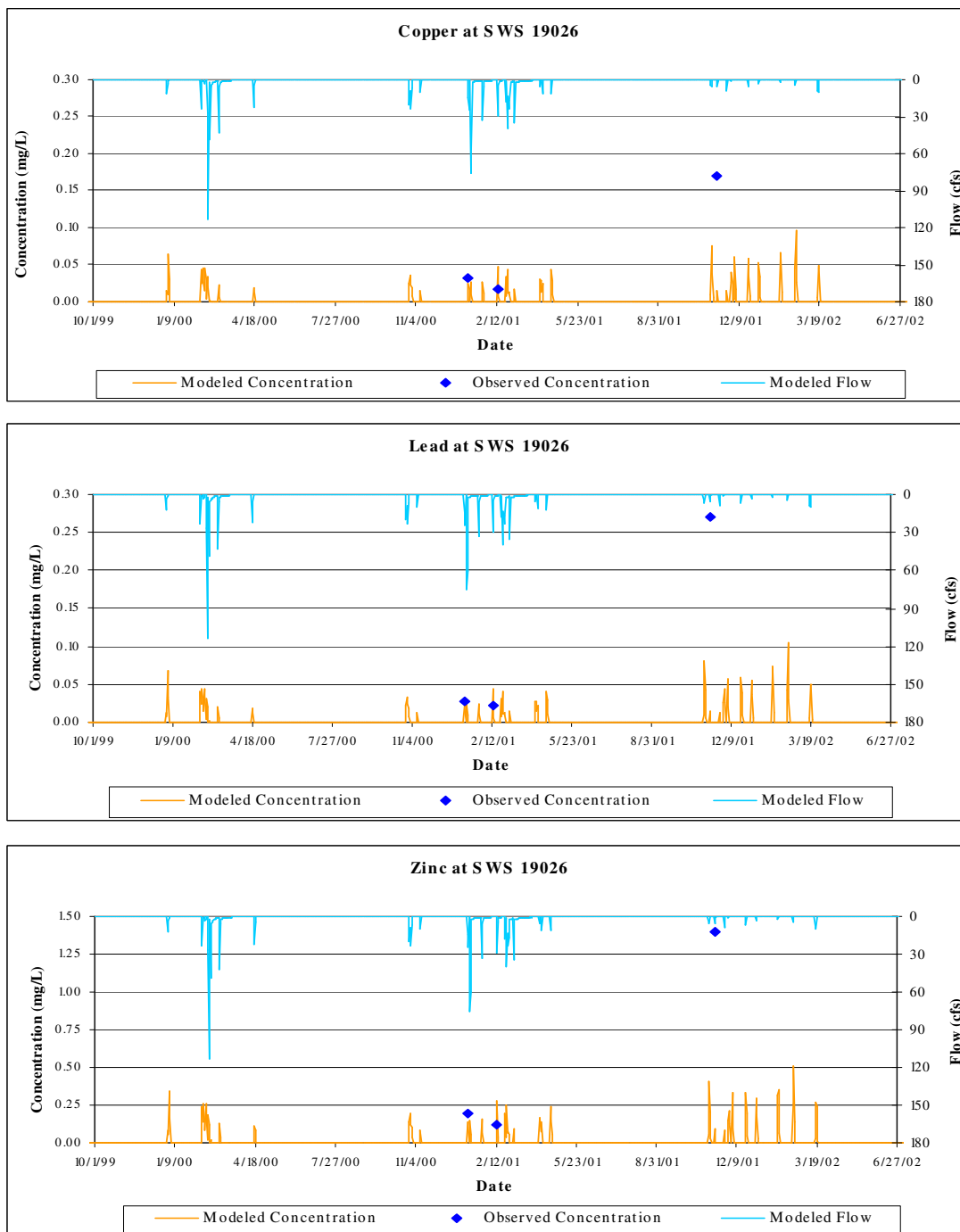


Figure 31. Time-series comparison of modeled and observed wet weather metals concentrations at sampling location DPR(1) (model validation)

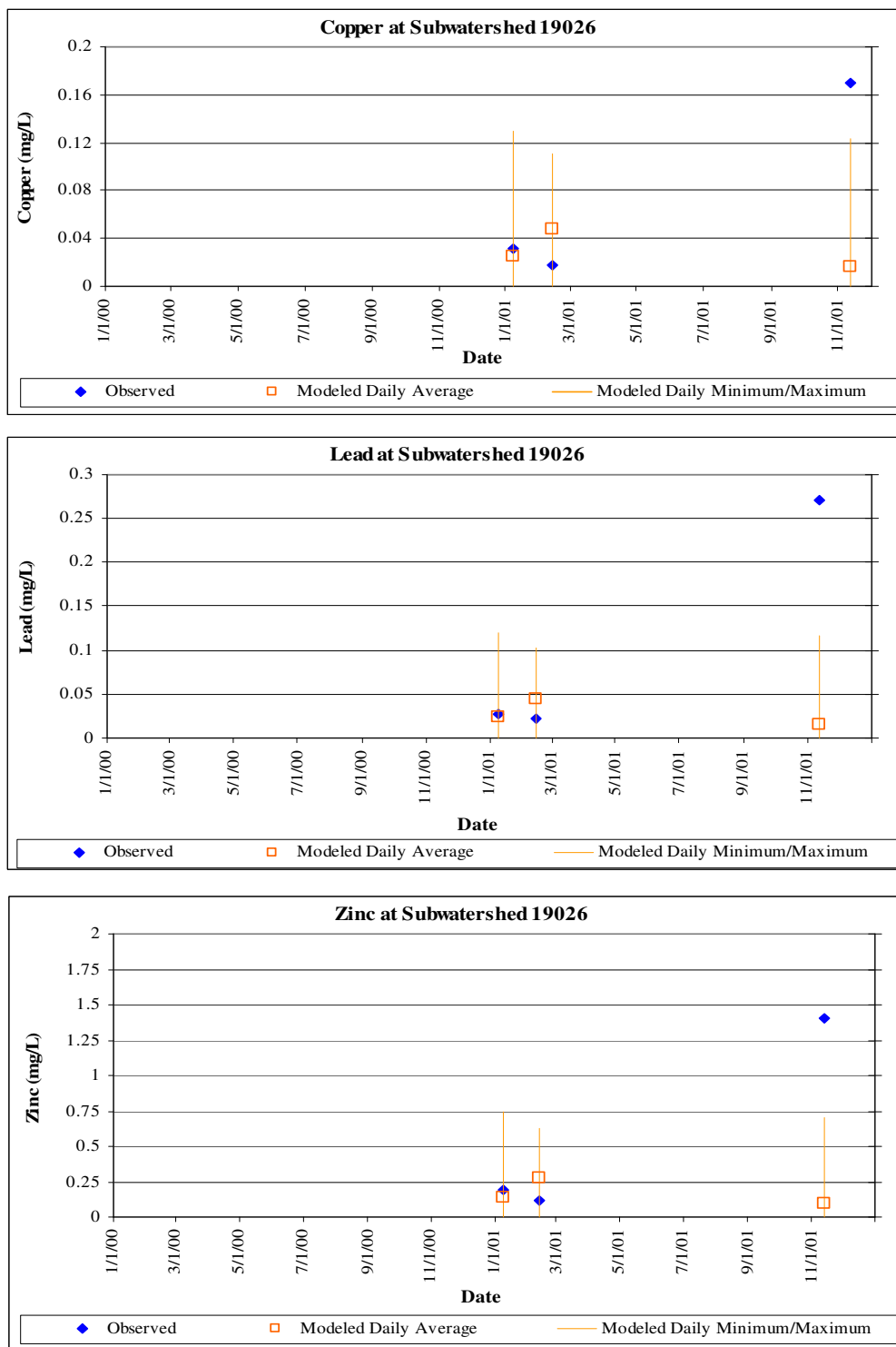


Figure 32. LSPC model results and corresponding observed metals data at sampling location DPR(1) (model validation)

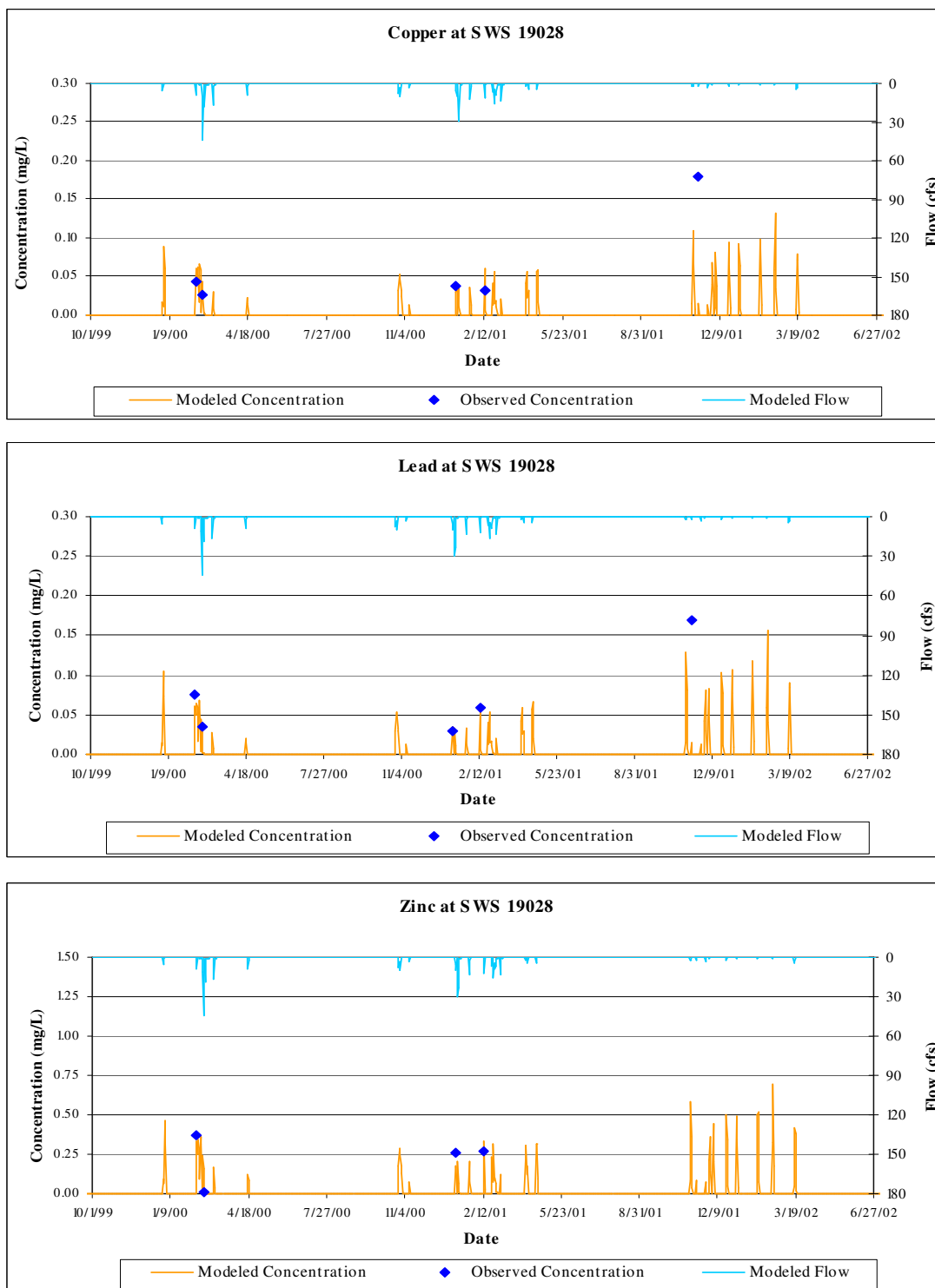


Figure 33. Time-series comparison of modeled and observed wet weather metals concentrations at sampling location SD8(5) (model validation)

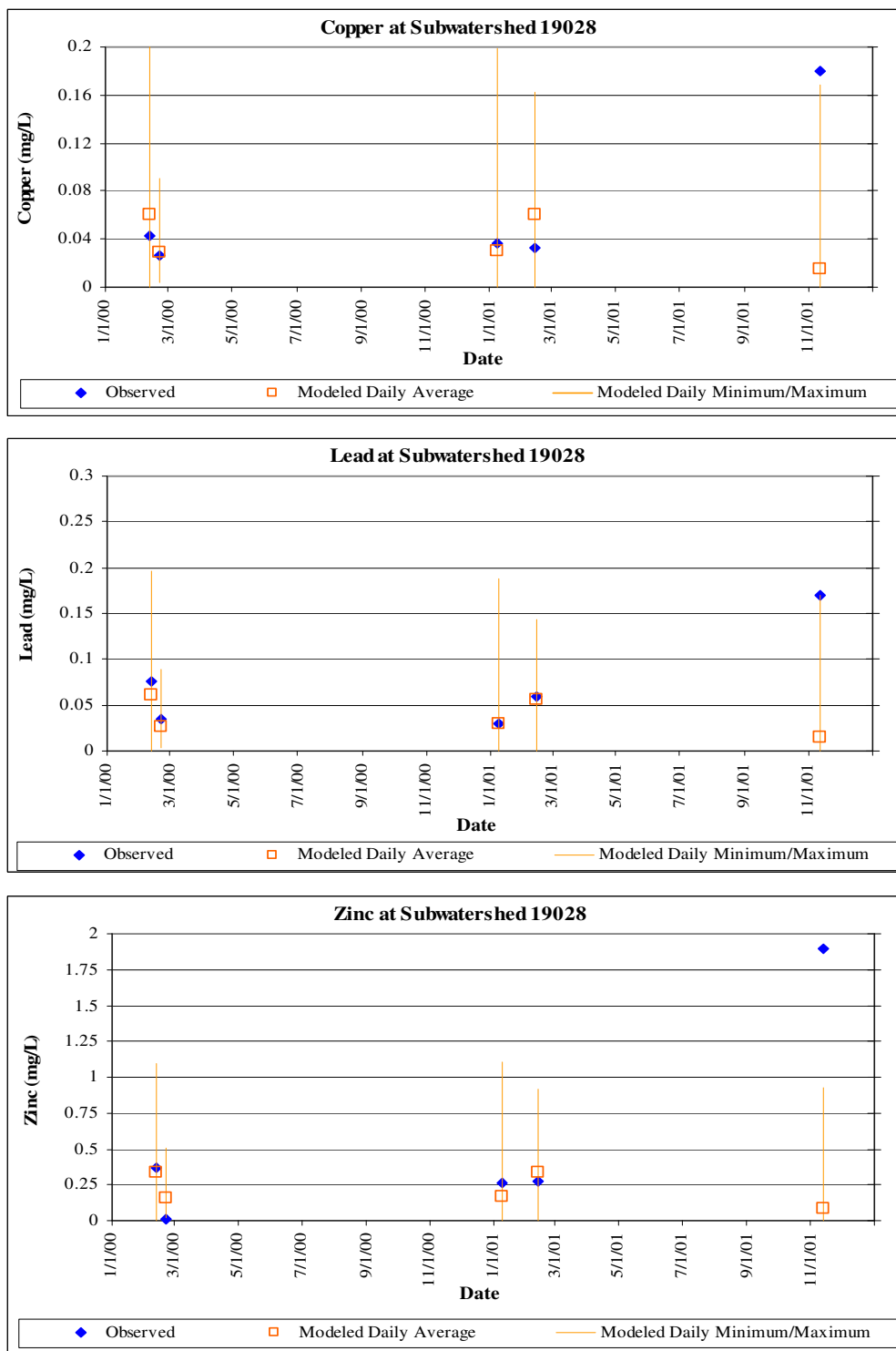


Figure 34. LSPC model results and corresponding observed metals data at sampling location SD8(5) (model validation)

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Appendix E

Land Use Loading Analyses

Used in the Chollas Creek Metals Total Maximum Daily Load

California Regional Water Quality Control Board, San Diego Region

PUBLIC REVIEW DRAFT

28 March 2005

Table E-1 presents descriptions of the land uses present in the Chollas Creek watershed. The original land uses categories were developed by the San Diego Association of Governments (SANDAG, 2000) and were reclassified for use in the water quality models.

Table E-1. Description of land uses in the Chollas Creek Watershed

Model Land Use Code	SANDAG Land Use Code	Land Use Description
1100	1000	Spaced Rural Residential - Homes in rural areas with lot sizes of approximately 1 to 10 acres
	1100	Single Family Residential - Single family detached housing units with lot sizes less than 1 acre
1200	1200	Multi-Family Residential - Attached housing units, two or more units per structure
	1300	Mobile Home Parks- 10 or more spaces that are primarily for residential use
	1403	Military Barracks
	1409	Other Group Quarters - Convalescent or retirement homes
	1501	Hotels, motels, and other transient accommodations with three or less floors
1400	5001	Wholesale Trade - Examples are clothing and supply, includes Swap meet areas
	5002	Regional Shopping Centers - Typically larger than 40 acres
	5003	Community Commercial - Smaller in size (8 to 20 acres) than the regional shopping centers
	5004	Neighborhood Shopping Centers- Usually less than 10 acres in size with on-site parking
	5007	Store-front Commercial - Commercial activities along major streets, with limited on-site parking
	5009	Other Retail - Other retail land uses not classified above
	6002	Office (Low Rise) - Buildings with less than 5 stories
	6003	Government/Civic Centers - Large government office buildings or centers; and civic centers
	6102	Churches
	6103	Libraries
	6104	Post Offices
	6105	Fire/Police/Ranger Stations
	6109	Other Public Services - Museums, art galleries, social service agencies, historic sites
	6502	Hospitals-General
	6509	Other Health Care - Medical centers, health care services, and other health care facilities
	6802	Universities and Colleges
	6803-6805	High Schools - Senior High Schools, Junior High Schools, Middle Schools
	6806	Elementary Schools
	6807	School District Offices
	6809	Other Schools - Includes adult schools, non-residential day care and nursery schools
	7205	Golf Course Clubhouses - Clubhouses, swimming and tennis facilities, and parking lots
1401	5006	Auto dealerships
1501	4113	Communications and Utilities - Broadcasting stations, relay towers, electrical generating plants, water and sewage treatment facilities
1502	4112	Freeway - Divided roadways with 4 or more lanes, and right-of-way widths greater than 200 ft.
1503	2001	Heavy Industry - Shipbuilding, airframe, and aircraft manufacturing
1505	2101	Industrial Parks - Office/Industrial Uses Clustered Into A Center
	2103	Light Industry, General - Includes manufacturing uses such as lumber, furniture, paper, rubber, stone, clay, and glass; auto repair services, and recycling centers
	2104	Warehousing/Public storage
1506	4120	Marine Terminals
1507	4119	Other Transportation - Maintenance yards, transit yards and walking bridges
1508	4114	Parking, Surface - All surface parking lots not associated with another land use
	4116	Park and Ride Lots- Stand-alone parking areas that are not associated with any land use
1509	4111	Rail Stations/Transit Centers/Seaports- Parking areas are included

Table E-1. *Continued*

Model Land Use Code	SANDAG Land Use Code	Land Use Description
1600	6701	Military Use
1700	7210	Other Recreation - RV parks, campgrounds, swim clubs, and Stand-alone movie theaters
	7601	Parks, Active- Tennis or basketball courts, baseball diamonds, soccer fields, or swings
	7606	Landscape, Open Space - Actively landscaped areas within residential neighborhoods
1800	6101	Cemetery
	7204	Golf Courses
2301	2301	Junkyard/Dumps/Landfills - Include auto wrecking/dismantling and recycling centers
4000	7603	Open Space Parks & Preserves
	9101	Vacant
5000	9201	Bays, Lagoons
	9202	Inland Water
7000	9501	Residential Under Construction
	9502	Commercial Under Construction
	9507	Freeway Under Construction

A land use distribution map is provided in Figure E-1.

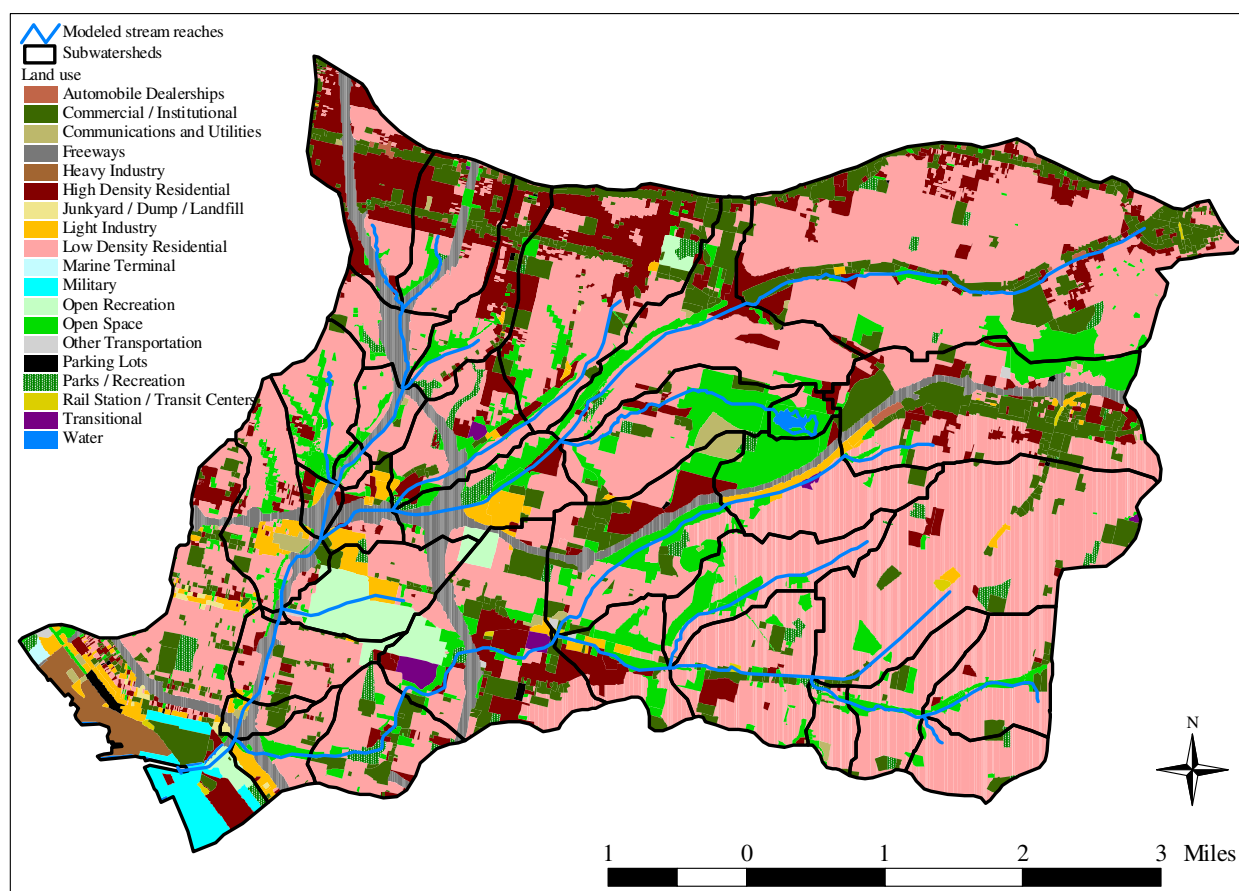


Figure E-1. Land uses in the Chollas Creek Watershed

To supplement Figure E-1, the land use areas (in square miles) associated with each subwatershed are presented in Table E-2. This table also presents the total area for each subwatershed, the total area for each land use, and the percent of total area associated with each land use.

Tables E-3 through E-5 present the average annual wet weather loadings of copper, lead, and zinc for each land use by subwatershed (average of 1990-2003 simulation results). Similarly, Tables E-6 through E-8 present the average relative copper, lead, and zinc load by land use for each subwatershed. These six tables will provide useful information for development of a TMDL implementation strategy by identifying areas and land uses that contribute the greatest copper, lead, and/or zinc loads.

Table E-2. Land use area (square miles) of each subwatershed

Sub-watershed Number	Low Density Residential (1100)	High Density Residential (1200)	Commercial / Institutional (1400)	Automobile Dealerships (1401)	Communications and Utilities (1501)	Freeways (1502)	Heavy Industry (1503)	Junkyard / Dump / Landfill (1504)	Light Industry (1505)	Marine Terminal (1506)	Other Transportation (1507)	Parking Lots (1508)	Rail Station / Transit Centers (1509)	Military (1600)	Parks / Recreation (1700)	Open Recreation (1800)	Open Space (4000)	Water (5000)	Transitional (7000)	Total Area
19001	0.56	0.20	0.29	0.00	0.01	0.11	0.21	0.03	0.14	0.02	0.01	0.03	0.01	0.24	0.05	0.05	0.06	0.02	0.00	2.01
19002	0.04	0.00	0.03	0.00	0.01	0.04	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.13
19003	0.33	0.03	0.05	0.00	0.00	0.04	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.49
19004	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
19005	0.36	0.04	0.05	0.00	0.03	0.09	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.70
19006	0.01	0.02	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.11
19007	0.31	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.46
19008	0.03	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.06
19009	0.16	0.00	0.01	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.25
19010	0.18	0.01	0.01	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.32
19011	0.17	0.42	0.11	0.01	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.86
19012	0.23	0.20	0.11	0.01	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.68
19013	0.19	0.17	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.05	0.00	0.00	0.52
19014	0.19	0.00	0.03	0.00	0.00	0.05	0.00	0.00	0.06	0.00	0.01	0.00	0.00	0.00	0.01	0.28	0.01	0.00	0.00	0.63
19015	0.06	0.02	0.02	0.00	0.00	0.06	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.23
19016	0.28	0.10	0.03	0.00	0.00	0.07	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.06	0.00	0.01	0.61
19017	0.70	0.45	0.29	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.11	0.00	0.00	1.62
19018	0.16	0.05	0.03	0.00	0.00	0.13	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.10	0.00	0.00	0.58
19019	0.77	0.12	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.14	0.00	0.00	1.22
19020	2.63	0.44	0.74	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.20	0.00	0.00	4.07
19021	0.43	0.03	0.06	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.24	0.00	0.00	0.82
19022	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.02	0.00	0.14
19023	0.15	0.00	0.01	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.29
19024	0.36	0.04	0.10	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.00	0.61
19025	0.47	0.25	0.23	0.00	0.01	0.13	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.02	0.13	0.11	0.00	0.07	1.43
19026	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19027	0.41	0.13	0.15	0.00	0.05	0.09	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.25	0.00	0.00	1.11
19028	0.46	0.02	0.02	0.00	0.00	0.04	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.21	0.00	0.01	0.82
19029	0.69	0.21	0.48	0.01	0.00	0.15	0.00	0.00	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	1.78
19030	0.23	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.51
19031	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.66
19032	0.64	0.05	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.00	0.00	0.86
19033	1.90	0.04	0.15	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.05	0.00	0.04	0.00	0.00	2.21
19034	0.14	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.18
19035	0.42	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.05	0.00	0.00	0.51
19036	0.51	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.63
19037	0.35	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.39
Total Area	15.06	3.15	3.45	0.04	0.17	1.52	0.21	0.03	0.65	0.02	0.03	0.04	0.03	0.24	0.43	0.53	2.78	0.04	0.09	28.52
Relative Area	52.81%	11.04%	12.08%	0.15%	0.60%	5.34%	0.73%	0.11%	2.28%	0.05%	0.10%	0.15%	0.12%	0.84%	1.52%	1.87%	9.73%	0.14%	0.33%	

Copper, Lead, and Zinc TMDLs for the Chollas Creek Watershed

Table E-3. Average annual wet weather loadings by land use for copper (grams per year)

Sub-watershed Number	Low Density Residential (1100)	High Density Residential (1200)	Commercial / Institutional (1400)	Automobile Dealerships (1401)	Communications and Utilities (1501)	Freeways (1502)	Heavy Industry (1503)	Junkyard / Dump / Landfill (1504)	Light Industry (1505)	Marine Terminal (1506)	Other Transportation (1507)	Parking Lots (1508)	Rail Station / Transit Centers (1509)	Military (1600)	Parks / Recreation (1700)	Open Recreation (1800)	Open Space (4000)	Transitional (7000)	Total Load
19001	116.91	413.23	9,125.79	98.74	158.55	5,559.78	1,258.60	1,493.39	1,231.38	116.06	183.73	8,733.47	1,242.39	0.00	0.35	0.00	0.00	0.00	29,732.37
19002	7.74	0.00	908.13	0.00	79.29	2,112.00	0.00	290.43	79.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,477.04
19003	69.12	59.44	1,517.27	0.00	0.00	2,328.64	0.00	0.00	51.95	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	4,026.43
19004	1.74	0.00	0.00	0.00	0.00	180.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	182.26
19005	85.57	83.51	1,673.39	0.00	345.10	4,729.43	0.00	0.00	453.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	7,370.01
19006	1.49	38.87	110.83	0.00	0.00	3,032.61	0.00	0.00	107.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,290.93
19007	75.12	32.40	199.48	0.00	0.00	36.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	343.12
19008	6.80	0.00	0.00	0.00	0.00	758.19	0.00	0.00	3.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	768.05
19009	38.14	0.00	232.71	0.00	32.65	2,689.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,993.18
19010	42.37	11.52	288.13	0.00	0.00	5,180.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	5,522.81
19011	40.55	876.08	3,435.48	646.64	23.32	7,491.26	0.00	0.00	3.06	0.00	0.00	94.60	0.00	0.00	0.01	0.00	0.00	0.00	12,610.99
19012	54.64	411.76	3,369.01	517.31	46.64	4,296.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	8,695.62
19013	45.93	354.18	2,559.99	77.57	0.00	180.52	0.00	0.00	30.61	0.00	0.00	663.45	0.00	0.00	0.11	0.00	0.00	0.00	3,912.37
19014	45.52	2.16	820.08	0.00	0.00	2,364.76	0.00	0.00	547.90	0.00	138.73	0.00	0.00	0.00	0.04	0.25	0.00	0.00	3,919.43
19015	14.34	43.91	609.54	0.00	0.00	3,140.97	0.00	0.00	483.61	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	4,292.41
19016	67.74	214.52	953.08	0.00	0.00	3,664.42	0.00	0.00	104.06	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.01	0.00	5,004.08
19017	167.16	925.03	9,553.37	0.00	0.00	0.00	0.00	41.50	82.65	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.01	0.00	10,569.93
19018	37.56	94.30	875.49	0.00	0.00	6,588.75	0.00	0.00	740.72	0.00	0.00	0.00	0.00	0.00	0.24	0.01	0.01	0.00	8,337.08
19019	184.32	246.20	5,385.94	0.00	41.98	0.00	0.00	0.00	0.00	0.00	0.00	94.60	0.00	0.00	0.07	0.00	0.01	0.00	5,953.11
19020	628.00	902.71	23,693.79	931.12	37.31	0.00	0.00	0.00	36.73	0.00	0.00	94.60	329.96	0.00	0.25	0.00	0.02	0.00	26,654.48
19021	103.73	69.11	1,917.22	0.00	545.63	0.00	0.00	0.00	33.66	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.02	0.00	2,669.42
19022	3.23	24.47	33.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	60.96
19023	30.69	8.59	387.63	0.00	0.00	2,256.40	0.00	83.01	375.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,142.15
19024	76.28	78.78	3,123.14	0.00	0.00	667.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	3,946.47
19025	112.60	515.43	7,181.27	0.00	107.26	6,805.39	0.00	0.00	140.80	0.00	33.03	2,084.95	329.96	0.00	0.13	0.11	0.01	0.01	17,310.94
19026	0.00	0.00	22.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	188.61	0.00	0.00	0.00	0.00	0.00	210.78
19027	98.50	261.31	4,632.39	0.00	671.56	4,855.81	0.00	0.00	48.97	0.00	72.66	473.83	424.26	0.00	0.16	0.00	0.02	0.00	11,539.48
19028	109.12	39.59	609.54	0.00	37.31	2,310.54	0.00	0.00	474.43	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.02	0.00	3,580.61
19029	165.83	426.16	15,260.20	1,008.69	41.98	7,906.52	0.00	0.00	296.90	0.00	99.10	473.83	471.31	0.00	0.02	0.00	0.02	0.00	26,150.56
19030	53.73	179.25	941.97	0.00	0.00	0.00	0.00	0.00	226.50	0.00	66.07	0.00	141.35	0.00	0.00	0.00	0.01	0.00	1,608.87
19031	123.46	0.00	55.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	178.89
19032	152.31	105.82	2,615.41	0.00	18.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	565.61	0.00	0.15	0.00	0.01	0.00	3,457.97
19033	453.96	77.75	4,831.86	0.00	0.00	0.00	0.00	0.00	168.35	0.00	0.00	284.21	1,178.27	0.00	0.33	0.00	0.00	0.00	6,994.74
19034	32.50	2.16	221.65	0.00	97.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	354.29
19035	99.08	0.00	1,019.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	1,118.68
19036	122.55	21.60	1,418.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	1,562.66
19037	84.08	0.00	509.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	593.90

Table E-4. Average annual wet weather loadings by land use for lead (grams per year)

Sub-watershed Number	Low Density Residential (1100)	High Density Residential (1200)	Commercial / Institutional (1400)	Automobile Dealerships (1401)	Communications and Utilities (1501)	Freeways (1502)	Heavy Industry (1503)	Junkyard / Dump / Landfill (1504)	Light Industry (1505)	Marine Terminal (1506)	Other Transportation (1507)	Parking Lots (1508)	Rail Station / Transit Centers (1509)	Military (1600)	Parks / Recreation (1700)	Open Recreation (1800)	Open Space (4000)	Transitional (7000)	Total Load
19001	291.73	559.84	5,689.73	26.38	86.99	6,273.81	404.30	479.69	1,216.23	37.28	106.22	5,610.64	399.07	0.00	0.06	0.00	0.00	0.00	21,181.97
19002	19.33	0.00	566.20	0.00	43.50	2,383.24	0.00	93.29	78.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,184.02
19003	172.49	80.53	945.99	0.00	0.00	2,627.70	0.00	0.00	51.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,878.01
19004	4.05	0.00	0.00	0.00	0.00	203.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	207.75
19005	199.03	112.80	1,042.93	0.00	189.34	5,336.82	0.00	0.00	447.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7,328.01
19006	3.47	52.51	69.07	0.00	0.00	3,422.08	0.00	0.00	105.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,652.86
19007	174.73	43.76	124.32	0.00	0.00	40.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	383.57
19008	15.81	0.00	0.00	0.00	0.00	855.57	0.00	0.00	3.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	874.39
19009	88.71	0.00	145.04	0.00	17.91	3,035.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,286.77
19010	98.55	15.56	179.57	0.00	0.00	5,846.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	6,139.77
19011	94.31	1,183.41	2,141.15	172.76	12.79	8,453.34	0.00	0.00	3.02	0.00	0.00	60.76	0.00	0.00	0.00	0.00	0.00	0.00	12,121.55
19012	127.09	556.21	2,099.72	138.21	25.59	4,847.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7,794.81
19013	106.84	478.42	1,595.50	20.73	0.00	203.70	0.00	0.00	30.21	0.00	0.00	426.17	0.00	0.00	0.02	0.00	0.00	0.00	2,861.59
19014	105.88	2.92	511.11	0.00	0.00	2,668.46	0.00	0.00	540.74	0.00	80.09	0.00	0.00	0.00	0.01	0.04	0.00	0.00	3,909.23
19015	33.36	59.32	379.89	0.00	0.00	3,544.35	0.00	0.00	477.29	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	4,494.22
19016	157.56	289.77	594.00	0.00	0.00	4,135.03	0.00	0.00	102.70	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	5,279.12
19017	388.80	1,249.54	5,829.44	0.00	0.00	0.00	0.00	13.33	81.57	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	7,562.71
19018	87.36	127.39	545.64	0.00	0.00	7,434.93	0.00	0.00	731.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	8,926.41
19019	428.72	332.56	3,356.76	0.00	23.03	0.00	0.00	0.00	0.00	0.00	0.00	60.76	0.00	0.00	0.01	0.00	0.00	0.00	4,201.85
19020	1,460.70	1,219.39	14,767.02	248.76	20.47	0.00	0.00	0.00	36.25	0.00	0.00	60.76	105.99	0.00	0.04	0.00	0.00	0.00	17,919.40
19021	241.26	93.35	1,194.90	0.00	299.37	0.00	0.00	0.00	33.23	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	1,862.11
19022	7.52	33.06	20.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61.30
19023	76.58	11.64	241.68	0.00	0.00	2,546.18	0.00	26.66	371.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,273.95
19024	190.35	106.73	1,947.21	0.00	0.00	753.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	2,998.06
19025	261.90	696.24	4,475.69	0.00	58.85	7,679.39	0.00	0.00	138.96	0.00	19.07	1,339.28	105.99	0.00	0.02	0.02	0.00	0.00	14,775.40
19026	0.00	0.00	13.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.58	0.00	0.00	0.00	0.00	0.00	74.40
19027	229.11	352.98	2,887.11	0.00	368.45	5,479.43	0.00	0.00	48.33	0.00	41.95	304.37	136.28	0.00	0.03	0.00	0.00	0.00	9,848.04
19028	253.80	53.48	379.89	0.00	20.47	2,607.27	0.00	0.00	468.23	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	3,783.16
19029	385.71	575.66	9,510.84	269.49	23.03	8,921.93	0.00	0.00	293.02	0.00	57.21	304.37	151.39	0.00	0.00	0.00	0.00	0.00	20,492.66
19030	124.97	242.13	587.07	0.00	0.00	0.00	0.00	0.00	223.54	0.00	38.14	0.00	45.40	0.00	0.00	0.00	0.00	0.00	1,261.26
19031	287.17	0.00	34.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	321.70
19032	354.28	142.94	1,630.04	0.00	10.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	181.68	0.00	0.02	0.00	0.00	0.00	2,319.21
19033	1,055.89	105.02	3,011.43	0.00	0.00	0.00	0.00	0.00	166.15	0.00	0.00	182.57	378.48	0.00	0.05	0.00	0.00	0.00	4,899.60
19034	75.60	2.92	138.14	0.00	53.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	270.40
19035	230.46	0.00	635.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	865.90
19036	285.04	29.17	884.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,198.29
19037	195.56	0.00	317.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	513.28

Table E-5. Average annual wet weather loadings by land use for zinc (grams per year)

Sub-watershed Number	Low Density Residential (1100)	High Density Residential (1200)	Commercial / Institutional (1400)	Auto-mobile Dealerships (1401)	Communications and Utilities (1501)	Freeways (1502)	Heavy Industry (1503)	Junkyard / Dump / Landfill (1504)	Light Industry (1505)	Marine Terminal (1506)	Other Transportation (1507)	Parking Lots (1508)	Rail Station / Transit Centers (1509)	Military (1600)	Parks / Recreation (1700)	Open Recreation (1800)	Open Space (4000)	Transitional (7000)	Total Load
19001	488.77	2,475.28	53,126.96	903.19	2,454.80	25,697.50	7,975.51	9,463.58	13,728.43	735.44	838.21	55,343.97	7,873.01	0.01	2.59	0.00	0.04	0.00	181,107.29
19002	32.38	0.00	5,286.81	0.00	1,227.56	9,761.73	0.00	1,840.47	885.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19,034.62
19003	288.99	356.07	8,832.99	0.00	0.00	10,763.04	0.00	0.00	579.16	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	20,820.35
19004	7.65	0.00	0.00	0.00	0.00	834.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	842.01
19005	375.89	501.67	9,745.51	0.00	5,343.02	21,859.59	0.00	0.00	5,053.83	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.00	42,879.59
19006	6.56	233.53	645.42	0.00	0.00	14,016.82	0.00	0.00	1,195.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	16,097.55
19007	330.00	194.62	1,161.71	0.00	0.00	166.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	1,853.35
19008	29.87	0.00	0.00	0.00	0.00	3,504.39	0.00	0.00	34.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	3,568.36
19009	167.55	0.00	1,355.28	0.00	505.50	12,431.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00	14,460.12
19010	186.12	69.19	1,677.99	0.00	0.00	23,945.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.01	0.00	25,879.37
19011	178.11	5,263.19	20,007.59	5,915.23	361.03	34,624.87	0.00	0.00	34.09	0.00	0.00	599.45	0.00	0.00	0.07	0.00	0.00	0.00	66,983.63
19012	240.03	2,473.74	19,620.45	4,732.18	722.06	19,857.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.03	0.00	47,645.99
19013	201.79	2,127.77	14,908.91	709.61	0.00	834.36	0.00	0.00	341.49	0.00	0.00	4,204.28	0.00	0.00	0.84	0.00	0.03	0.00	23,329.09
19014	199.96	12.97	4,775.97	0.00	0.00	10,929.98	0.00	0.00	6,112.53	0.00	633.76	0.00	0.00	0.00	0.30	1.81	0.01	0.00	22,667.29
19015	63.01	263.81	3,549.84	0.00	0.00	14,517.66	0.00	0.00	5,395.32	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.01	0.00	23,789.94
19016	297.58	1,288.76	5,550.54	0.00	0.00	16,937.09	0.00	0.00	1,160.97	0.00	0.00	0.00	0.00	0.00	1.84	0.00	0.04	0.01	25,236.82
19017	734.30	5,557.27	54,472.23	0.00	0.00	0.00	0.00	263.01	922.05	0.00	0.00	0.00	0.00	0.00	1.31	0.22	0.07	0.00	61,950.45
19018	165.00	566.55	5,098.68	0.00	0.00	30,453.44	0.00	0.00	8,263.72	0.00	0.00	0.00	0.00	0.00	1.82	0.07	0.06	0.00	44,549.34
19019	809.69	1,479.06	31,366.66	0.00	649.98	0.00	0.00	0.00	0.00	0.00	0.00	599.45	0.00	0.00	0.53	0.00	0.09	0.00	34,905.46
19020	2,758.71	5,423.21	137,987.99	8,517.50	577.58	0.00	0.00	0.00	409.82	0.00	0.00	599.45	2,090.95	0.00	1.89	0.00	0.13	0.00	158,367.23
19021	455.66	415.18	11,165.50	0.00	8,447.80	0.00	0.00	0.00	375.57	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.15	0.00	20,860.26
19022	14.20	147.03	193.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.06	0.00	354.90
19023	128.30	51.48	2,256.66	0.00	0.00	10,429.14	0.00	526.02	4,189.99	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00	17,581.64
19024	318.92	471.89	18,181.74	0.00	0.00	3,087.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52	0.00	0.03	0.00	22,062.30
19025	494.63	3,096.51	41,822.31	0.00	1,660.66	31,454.75	0.00	0.00	1,570.78	0.00	150.91	13,212.30	2,090.95	0.00	0.99	0.82	0.07	0.05	95,555.73
19026	0.00	0.00	129.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,195.21	0.00	0.00	0.00	0.00	0.00	1,324.35
19027	432.71	1,569.88	26,978.12	0.00	10,397.42	22,443.72	0.00	0.00	546.32	0.00	331.94	3,002.67	2,688.55	0.00	1.20	0.00	0.16	0.00	68,392.69
19028	479.33	237.87	3,549.84	0.00	577.58	10,679.38	0.00	0.00	5,292.90	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.13	0.01	20,817.57
19029	728.47	2,560.24	88,872.44	9,227.12	649.98	36,544.20	0.00	0.00	3,312.31	0.00	452.72	3,002.67	2,986.68	0.00	0.11	0.00	0.11	0.00	148,337.05
19030	236.02	1,076.86	5,485.82	0.00	0.00	0.00	0.00	0.00	2,526.91	0.00	301.82	0.00	895.74	0.00	0.00	0.00	0.09	0.00	10,523.25
19031	542.35	0.00	322.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.09	0.00	865.18
19032	669.10	635.74	15,231.62	0.00	288.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,584.29	0.00	1.09	0.00	0.04	0.00	20,410.82
19033	1,994.18	467.08	28,139.82	0.00	0.00	0.00	0.00	0.00	1,878.18	0.00	0.00	1,801.06	7,466.71	0.00	2.48	0.00	0.03	0.00	41,749.54
19034	142.78	12.97	1,290.85	0.00	1,516.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.01	0.00	2,963.12
19035	435.26	0.00	5,937.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.03	0.00	6,373.29
19036	538.34	129.75	8,261.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.04	0.00	8,929.28
19037	369.33	0.00	2,968.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.01	0.00	3,338.55

Table E-6. Relative copper loadings for each land use by subwatershed (percent)

Sub-watershed Number	Low Density Residential (1100)	High Density Residential (1200)	Commercial / Institutional (1400)	Automobile Dealerships (1401)	Communications and Utilities (1501)	Freeways (1502)	Heavy Industry (1503)	Junkyard / Dump / Landfill (1504)	Light Industry (1505)	Marine Terminal (1506)	Other Transportation (1507)	Parking Lots (1508)	Rail Station / Transit Centers (1509)	Military (1600)	Parks / Recreation (1700)	Open Recreation (1800)	Open Space (4000)	Transitional (7000)	Total Relative Subwatershed Loading
19001	0.33	30.69	0.53	18.70	4.23	1.39	5.02	4.14	0.39	0.39	0.00	0.00	0.00	0.62	29.37	0.00	4.18	0.00	12.81
19002	0.00	26.12	2.28	60.74	0.00	0.00	8.35	2.28	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50
19003	0.00	37.68	0.00	57.83	0.00	1.48	0.00	1.29	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.73
19004	0.00	0.00	0.00	99.04	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
19005	0.00	22.71	4.68	64.17	0.00	1.13	0.00	6.15	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.17
19006	0.00	3.37	0.00	92.15	0.00	1.18	0.00	3.26	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.42
19007	0.00	58.14	0.00	10.53	0.00	9.44	0.00	0.00	21.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
19008	0.00	0.00	0.00	98.72	0.00	0.00	0.00	0.40	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
19009	0.00	7.77	1.09	89.86	0.00	0.00	0.00	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29
19010	0.00	5.22	0.00	93.81	0.00	0.21	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38
19011	5.13	27.24	0.18	59.40	0.00	6.95	0.00	0.02	0.32	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	5.43
19012	5.95	38.74	0.54	49.41	0.00	4.74	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.75
19013	1.98	65.43	0.00	4.61	0.00	9.05	0.00	0.78	1.17	0.00	0.00	0.00	0.00	0.00	16.96	0.00	0.00	0.00	1.69
19014	0.00	20.92	0.00	60.33	0.00	0.06	0.00	13.98	1.16	0.00	0.00	0.00	0.01	3.54	0.00	0.00	0.00	0.00	1.69
19015	0.00	14.20	0.00	73.17	0.00	1.02	0.00	11.27	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85
19016	0.00	19.05	0.00	73.23	0.00	4.29	0.00	2.08	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.16
19017	0.00	88.49	0.00	0.00	0.00	8.75	0.39	0.78	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.55
19018	0.00	10.50	0.00	79.03	0.00	1.13	0.00	8.88	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.59
19019	0.00	90.47	0.71	0.00	0.00	4.14	0.00	0.00	3.10	0.00	0.00	0.00	0.00	0.00	1.59	0.00	0.00	0.00	2.56
19020	3.49	88.89	0.14	0.00	0.00	3.39	0.00	0.14	2.36	0.00	0.00	0.00	0.00	0.00	0.35	0.00	1.24	0.00	11.48
19021	0.00	71.82	20.44	0.00	0.00	2.59	0.00	1.26	3.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.15
19022	0.00	54.53	0.00	0.00	0.00	40.15	0.00	0.00	5.30	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.03
19023	0.00	12.34	0.00	71.81	0.00	0.27	2.64	11.96	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35
19024	0.00	79.14	0.00	16.92	0.00	2.00	0.00	0.00	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	1.70
19025	0.00	41.48	0.62	39.31	0.00	2.98	0.00	0.81	0.65	0.00	0.00	0.00	0.00	0.19	12.04	0.00	1.91	0.00	7.46
19026	0.00	10.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	89.48	0.00	0.09
19027	0.00	40.14	5.82	42.08	0.00	2.26	0.00	0.42	0.85	0.00	0.00	0.00	0.00	0.63	4.11	0.00	3.68	0.00	4.97
19028	0.00	17.02	1.04	64.53	0.00	1.11	0.00	13.25	3.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54
19029	3.86	58.36	0.16	30.23	0.00	1.63	0.00	1.14	0.63	0.00	0.00	0.00	0.00	0.38	1.81	0.00	1.80	0.00	11.27
19030	0.00	58.55	0.00	0.00	0.00	11.14	0.00	14.08	3.34	0.00	0.00	0.00	0.00	4.11	0.00	0.00	8.79	0.00	0.69
19031	0.00	30.98	0.00	0.00	0.00	0.00	0.00	0.00	69.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.08
19032	0.00	75.63	0.54	0.00	0.00	3.06	0.00	0.00	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.36	0.00	1.49
19033	0.00	69.08	0.00	0.00	0.00	1.11	0.00	2.41	6.49	0.00	0.00	0.00	0.00	0.00	4.06	0.00	16.85	0.00	3.01
19034	0.00	62.56	27.64	0.00	0.00	0.61	0.00	0.00	9.17	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.15
19035	0.00	91.14	0.00	0.00	0.00	0.00	0.00	0.00	8.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48
19036	0.00	90.77	0.00	0.00	0.00	1.38	0.00	0.00	7.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
19037	0.00	85.83	0.00	0.00	0.00	0.00	0.00	0.00	14.16	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.26

Table E-7. Relative lead loadings for each land use by subwatershed (percent)

Sub-watershed Number	Low Density Residential (1100)	High Density Residential (1200)	Commercial / Institutional (1400)	Automobile Dealerships (1401)	Communications and Utilities (1501)	Freeways (1502)	Heavy Industry (1503)	Junkyard / Dump / Landfill (1504)	Light Industry (1505)	Marine Terminal (1506)	Other Transportation (1507)	Parking Lots (1508)	Rail Station / Transit Centers (1509)	Military (1600)	Parks / Recreation (1700)	Open Recreation (1800)	Open Space (4000)	Transitional (7000)	Total Relative Subwatershed Loading
19001	0.12	26.86	0.41	29.62	1.91	2.64	2.26	5.74	1.38	0.18	0.00	0.00	0.00	0.50	26.49	0.00	1.88	0.00	10.92
19002	0.00	17.78	1.37	74.85	0.00	0.00	2.93	2.46	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.64
19003	0.00	24.39	0.00	67.76	0.00	2.08	0.00	1.32	4.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
19004	0.00	0.00	0.00	98.05	0.00	0.00	0.00	0.00	1.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
19005	0.00	14.23	2.58	72.83	0.00	1.54	0.00	6.10	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.78
19006	0.00	1.89	0.00	93.68	0.00	1.44	0.00	2.89	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.88
19007	0.00	32.41	0.00	10.63	0.00	11.41	0.00	0.00	45.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
19008	0.00	0.00	0.00	97.85	0.00	0.00	0.00	0.34	1.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
19009	0.00	4.41	0.55	92.34	0.00	0.00	0.00	0.00	2.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69
19010	0.00	2.92	0.00	95.22	0.00	0.25	0.00	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.16
19011	1.43	17.66	0.11	69.74	0.00	9.76	0.00	0.02	0.78	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	6.25
19012	1.77	26.94	0.33	62.20	0.00	7.14	0.00	0.00	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.02
19013	0.72	55.76	0.00	7.12	0.00	16.72	0.00	1.06	3.73	0.00	0.00	0.00	0.00	0.00	14.89	0.00	0.00	0.00	1.47
19014	0.00	13.07	0.00	68.26	0.00	0.07	0.00	13.83	2.71	0.00	0.00	0.00	0.00	2.05	0.00	0.00	0.00	0.00	2.01
19015	0.00	8.45	0.00	78.86	0.00	1.32	0.00	10.62	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.32
19016	0.00	11.25	0.00	78.33	0.00	5.49	0.00	1.95	2.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.72
19017	0.00	77.08	0.00	0.00	0.00	16.52	0.18	1.08	5.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.90
19018	0.00	6.11	0.00	83.29	0.00	1.43	0.00	8.19	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.60
19019	0.00	79.89	0.55	0.00	0.00	7.91	0.00	0.00	10.20	0.00	0.00	0.00	0.00	0.00	1.45	0.00	0.00	0.00	2.17
19020	1.39	82.41	0.11	0.00	0.00	6.80	0.00	0.20	8.15	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.59	0.00	9.24
19021	0.00	64.17	16.08	0.00	0.00	5.01	0.00	1.78	12.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96
19022	0.00	33.79	0.00	0.00	0.00	53.93	0.00	0.00	12.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
19023	0.00	7.38	0.00	77.77	0.00	0.36	0.81	11.34	2.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69
19024	0.00	64.95	0.00	25.14	0.00	3.56	0.00	0.00	6.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55
19025	0.00	30.29	0.40	51.97	0.00	4.71	0.00	0.94	1.77	0.00	0.00	0.00	0.00	0.13	9.06	0.00	0.72	0.00	7.62
19026	0.00	18.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	81.43	0.00	0.04
19027	0.00	29.32	3.74	55.64	0.00	3.58	0.00	0.49	2.33	0.00	0.00	0.00	0.00	0.43	3.09	0.00	1.38	0.00	5.08
19028	0.00	10.04	0.54	68.92	0.00	1.41	0.00	12.38	6.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95
19029	1.32	46.41	0.11	43.54	0.00	2.81	0.00	1.43	1.88	0.00	0.00	0.00	0.00	0.28	1.49	0.00	0.74	0.00	10.56
19030	0.00	46.55	0.00	0.00	0.00	19.20	0.00	17.72	9.91	0.00	0.00	0.00	0.00	3.02	0.00	0.00	3.60	0.00	0.65
19031	0.00	10.74	0.00	0.00	0.00	0.00	0.00	0.00	89.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
19032	0.00	70.28	0.44	0.00	0.00	6.16	0.00	0.00	15.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.83	0.00	1.20
19033	0.00	61.46	0.00	0.00	0.00	2.14	0.00	3.39	21.55	0.00	0.00	0.00	0.00	0.00	3.73	0.00	7.72	0.00	2.53
19034	0.00	51.09	19.87	0.00	0.00	1.08	0.00	0.00	27.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
19035	0.00	73.38	0.00	0.00	0.00	0.00	0.00	0.00	26.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
19036	0.00	73.78	0.00	0.00	0.00	2.43	0.00	0.00	23.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
19037	0.00	61.90	0.00	0.00	0.00	0.00	0.00	0.00	38.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26

Copper, Lead, and Zinc TMDLs for the Chollas Creek Watershed

Table E-8. Relative zinc loadings for each land use by subwatershed (percent)

Sub-watershed Number	Low Density Residential (1100)	High Density Residential (1200)	Commercial/Institutional (1400)	Automobile Dealerships (1401)	Communications and Utilities (1501)	Freeways (1502)	Heavy Industry (1503)	Junkyard/Dump/Landfill (1504)	Light Industry (1505)	Marine Terminal (1506)	Other Transportation (1507)	Parking Lots (1508)	Rail Station/Transit Centers (1509)	Military (1600)	Parks / Recreation (1700)	Open Recreation (1800)	Open Space (4000)	Transitional (7000)	Total Relative Subwatershed Loading
19001	0.50	29.33	1.36	14.19	4.40	1.37	5.23	7.58	0.27	0.41	0.00	0.00	0.00	0.46	30.56	0.00	4.35	0.00	13.65
19002	0.00	27.77	6.45	51.28	0.00	0.00	9.67	4.65	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.44
19003	0.00	42.42	0.00	51.69	0.00	1.71	0.00	2.78	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57
19004	0.00	0.00	0.00	99.09	0.00	0.00	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
19005	0.00	22.73	12.46	50.98	0.00	1.17	0.00	11.79	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23
19006	0.00	4.01	0.00	87.07	0.00	1.45	0.00	7.42	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.21
19007	0.00	62.68	0.00	9.01	0.00	10.50	0.00	0.00	17.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
19008	0.00	0.00	0.00	98.21	0.00	0.00	0.00	0.96	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27
19009	0.00	9.37	3.50	85.97	0.00	0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.09
19010	0.00	6.48	0.00	92.53	0.00	0.27	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95
19011	8.83	29.87	0.54	51.69	0.00	7.86	0.00	0.05	0.27	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.00	0.00	5.05
19012	9.93	41.18	1.52	41.68	0.00	5.19	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.59
19013	3.04	63.91	0.00	3.58	0.00	9.12	0.00	1.46	0.86	0.00	0.00	0.00	0.00	0.00	18.02	0.00	0.00	0.00	1.76
19014	0.00	21.07	0.00	48.22	0.00	0.06	0.00	26.97	0.88	0.00	0.00	0.00	0.01	2.80	0.00	0.00	0.00	0.00	1.71
19015	0.00	14.92	0.00	61.02	0.00	1.11	0.00	22.68	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79
19016	0.00	21.99	0.00	67.11	0.00	5.11	0.00	4.60	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	1.90
19017	0.00	87.93	0.00	0.00	0.00	8.97	0.42	1.49	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.67
19018	0.00	11.45	0.00	68.36	0.00	1.27	0.00	18.55	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.36
19019	0.00	89.86	1.86	0.00	0.00	4.24	0.00	0.00	2.32	0.00	0.00	0.00	0.00	0.00	1.72	0.00	0.00	0.00	2.63
19020	5.38	87.13	0.36	0.00	0.00	3.42	0.00	0.26	1.74	0.00	0.00	0.00	0.00	0.00	0.38	0.00	1.32	0.00	11.94
19021	0.00	53.53	40.50	0.00	0.00	1.99	0.00	1.80	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57
19022	0.00	54.54	0.00	0.00	0.00	41.43	0.00	0.00	4.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.03
19023	0.00	12.84	0.00	59.32	0.00	0.29	2.99	23.83	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33
19024	0.00	82.41	0.00	13.99	0.00	2.14	0.00	0.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	1.66
19025	0.00	43.77	1.74	32.92	0.00	3.24	0.00	1.64	0.52	0.00	0.00	0.00	0.00	0.16	13.83	0.00	2.19	0.00	7.20
19026	0.00	9.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	90.25	0.00	0.10
19027	0.00	39.45	15.20	32.82	0.00	2.30	0.00	0.80	0.63	0.00	0.00	0.00	0.00	0.49	4.39	0.00	3.93	0.00	5.16
19028	0.00	17.05	2.77	51.30	0.00	1.14	0.00	25.43	2.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57
19029	6.22	59.91	0.44	24.64	0.00	1.73	0.00	2.23	0.49	0.00	0.00	0.00	0.00	0.31	2.02	0.00	2.01	0.00	11.18
19030	0.00	52.13	0.00	0.00	0.00	10.23	0.00	24.01	2.24	0.00	0.00	0.00	0.00	2.87	0.00	0.00	8.51	0.00	0.79
19031	0.00	37.30	0.00	0.00	0.00	0.00	0.00	0.00	62.69	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.07
19032	0.00	74.63	1.42	0.00	0.00	3.11	0.00	0.00	3.28	0.00	0.00	0.00	0.00	0.00	0.00	0.01	17.56	0.00	1.54
19033	0.00	67.40	0.00	0.00	0.00	1.12	0.00	4.50	4.78	0.00	0.00	0.00	0.00	0.00	4.31	0.01	17.88	0.00	3.15
19034	0.00	43.56	51.17	0.00	0.00	0.44	0.00	0.00	4.82	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.22
19035	0.00	93.17	0.00	0.00	0.00	0.00	0.00	0.00	6.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48
19036	0.00	92.52	0.00	0.00	0.00	1.45	0.00	0.00	6.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
19037	0.00	88.93	0.00	0.00	0.00	0.00	0.00	0.00	11.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.25

Appendix F

**Statistical Comparison of Measured
Values and Modeled Values for
Flow and Water Quality**

Used in the Chollas Creek Metals Total Maximum Daily Load

California Regional Water Quality Control Board, San Diego Region

PUBLIC REVIEW DRAFT
28 March 2005

Introduction

This appendix compares measured flow and water quality values against those generated from model runs. Data are presented side-by-side for direct comparison. Simple statistical comparisons are also offered.

Flow

Table F-1 lists all modeled and measured values from November 1, 2001 to December 30, 2003 for the Chollas Creek Watershed. Table F-2 shows all observed values above 2.28 cubic feet per second (cfs), which is the definition of wet weather conditions, and the corresponding modeled average flows. Also in Table F-2 are the percent and actual differences. Table F-3 gives the total volume per day in cubic feet (cf) for corresponding dates in Table F-2. Figure F-1 plots volume per day from the model versus volume per day from the observed values. The R^2 value is 0.7035 for 26 data pairs. Table F-4 gives the total volume for the 28 days in liters for modeled and observed values and the percent differences and actual differences between the two. Table F-5 gives summary statistics of the 26 values in both the modeled and observed value data sets and from the percent differences and actual differences.

Water Quality

Tables F-6 and F-7 show the measured water quality data and the corresponding model results. Tables F-8 and F-9 show the percent and actual differences of the water quality data that corresponds with flows over 2.28 cfs. Tables F-10 and F-11 show the five dates that both measured flow and water quality data were available. The loads per day were calculated and compared, by percent and actual difference, with the model values for the same days.

Table F-1. All modeled and measured values. Observed values have approximately the same significant figures as the original values in copermittees reports.

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2001	11	1	11/1/01	0.000	
2001	11	2	11/2/01	0.000	
2001	11	3	11/3/01	0.000	
2001	11	4	11/4/01	6.723	
2001	11	5	11/5/01	13.326	
2001	11	6	11/6/01	0.082	
2001	11	7	11/7/01	0.080	
2001	11	8	11/8/01	0.059	
2001	11	9	11/9/01	0.060	
2001	11	10	11/10/01	0.069	
2001	11	11	11/11/01	0.059	
2001	11	12	11/12/01	10.591	
2001	11	13	11/13/01	1.907	
2001	11	14	11/14/01	0.099	
2001	11	15	11/15/01	0.088	
2001	11	16	11/16/01	0.090	
2001	11	17	11/17/01	0.091	
2001	11	18	11/18/01	0.087	
2001	11	19	11/19/01	0.074	
2001	11	20	11/20/01	0.075	
2001	11	21	11/21/01	0.076	
2001	11	22	11/22/01	0.077	
2001	11	23	11/23/01	0.074	
2001	11	24	11/24/01	15.867	
2001	11	25	11/25/01	0.791	
2001	11	26	11/26/01	0.133	
2001	11	27	11/27/01	0.106	
2001	11	28	11/28/01	0.114	0
2001	11	29	11/29/01	2.801	18
2001	11	30	11/30/01	0.207	
2001	12	1	12/1/01	0.126	
2001	12	2	12/2/01	0.112	
2001	12	3	12/3/01	0.183	
2001	12	4	12/4/01	0.570	
2001	12	5	12/5/01	0.115	
2001	12	6	12/6/01	0.086	
2001	12	7	12/7/01	0.047	
2001	12	8	12/8/01	0.005	
2001	12	9	12/9/01	0.070	
2001	12	10	12/10/01	0.085	
2001	12	11	12/11/01	0.073	
2001	12	12	12/12/01	0.073	
2001	12	13	12/13/01	0.070	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2001	12	14	12/14/01	0.082	
2001	12	15	12/15/01	0.061	
2001	12	16	12/16/01	0.058	
2001	12	17	12/17/01	0.052	
2001	12	18	12/18/01	0.053	
2001	12	19	12/19/01	0.048	
2001	12	20	12/20/01	0.054	
2001	12	21	12/21/01	11.824	
2001	12	22	12/22/01	0.134	
2001	12	23	12/23/01	0.108	
2001	12	24	12/24/01	0.081	
2001	12	25	12/25/01	0.082	
2001	12	26	12/26/01	0.078	
2001	12	27	12/27/01	0.079	
2001	12	28	12/28/01	0.084	
2001	12	29	12/29/01	0.080	
2001	12	30	12/30/01	0.073	
2001	12	31	12/31/01	0.084	
2002	1	1	1/1/02	0.070	
2002	1	2	1/2/02	0.064	
2002	1	3	1/3/02	5.539	
2002	1	4	1/4/02	0.084	
2002	1	5	1/5/02	0.077	
2002	1	6	1/6/02	0.068	
2002	1	7	1/7/02	0.054	
2002	1	8	1/8/02	0.055	
2002	1	9	1/9/02	0.067	
2002	1	10	1/10/02	0.054	
2002	1	11	1/11/02	0.047	
2002	1	12	1/12/02	0.031	
2002	1	13	1/13/02	0.044	
2002	1	14	1/14/02	0.048	
2002	1	15	1/15/02	0.054	
2002	1	16	1/16/02	0.044	
2002	1	17	1/17/02	0.042	
2002	1	18	1/18/02	0.040	
2002	1	19	1/19/02	0.036	
2002	1	20	1/20/02	0.037	
2002	1	21	1/21/02	0.033	
2002	1	22	1/22/02	0.034	
2002	1	23	1/23/02	0.027	
2002	1	24	1/24/02	0.024	
2002	1	25	1/25/02	0.026	
2002	1	26	1/26/02	0.028	
2002	1	27	1/27/02	0.027	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2002	1	28	1/28/02	0.026	
2002	1	29	1/29/02	4.119	
2002	1	30	1/30/02	0.057	
2002	1	31	1/31/02	0.043	
2002	2	1	2/1/02	0.035	
2002	2	2	2/2/02	0.032	
2002	2	3	2/3/02	0.032	
2002	2	4	2/4/02	0.029	
2002	2	5	2/5/02	0.026	
2002	2	6	2/6/02	0.028	
2002	2	7	2/7/02	0.027	
2002	2	8	2/8/02	0.028	
2002	2	9	2/9/02	0.013	
2002	2	10	2/10/02	0.000	
2002	2	11	2/11/02	0.013	
2002	2	12	2/12/02	0.017	
2002	2	13	2/13/02	0.020	
2002	2	14	2/14/02	0.020	
2002	2	15	2/15/02	0.019	
2002	2	16	2/16/02	0.021	
2002	2	17	2/17/02	7.614	3
2002	2	18	2/18/02	0.401	
2002	2	19	2/19/02	0.055	
2002	2	20	2/20/02	0.041	
2002	2	21	2/21/02	0.021	
2002	2	22	2/22/02	0.012	
2002	2	23	2/23/02	0.036	
2002	2	24	2/24/02	0.034	
2002	2	25	2/25/02	0.032	
2002	2	26	2/26/02	0.015	
2002	2	27	2/27/02	0.024	
2002	2	28	2/28/02	0.029	
2002	3	1	3/1/02	0.028	
2002	3	2	3/2/02	0.023	
2002	3	3	3/3/02	0.021	
2002	3	4	3/4/02	0.021	
2002	3	5	3/5/02	0.023	
2002	3	6	3/6/02	0.024	
2002	3	7	3/7/02	0.023	7
2002	3	8	3/8/02	0.021	1
2002	3	9	3/9/02	0.018	
2002	3	10	3/10/02	0.018	
2002	3	11	3/11/02	0.018	
2002	3	12	3/12/02	0.016	
2002	3	13	3/13/02	0.018	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2002	3	14	3/14/02	0.016	
2002	3	15	3/15/02	0.014	
2002	3	16	3/16/02	0.014	
2002	3	17	3/17/02	14.441	
2002	3	18	3/18/02	22.644	
2002	3	19	3/19/02	0.136	
2002	3	20	3/20/02	0.124	
2002	3	21	3/21/02	0.113	
2002	3	22	3/22/02	0.107	
2002	3	23	3/23/02	0.110	
2002	3	24	3/24/02	0.098	
2002	3	25	3/25/02	0.093	
2002	3	26	3/26/02	0.089	
2002	3	27	3/27/02	0.097	
2002	3	28	3/28/02	0.122	
2002	3	29	3/29/02	0.083	
2002	3	30	3/30/02	0.085	
2002	3	31	3/31/02	0.071	
2002	4	1	4/1/02	0.068	
2002	4	2	4/2/02	0.069	
2002	4	3	4/3/02	0.071	
2002	4	4	4/4/02	0.063	
2002	4	5	4/5/02	0.069	
2002	4	6	4/6/02	0.058	
2002	4	7	4/7/02	0.052	
2002	4	8	4/8/02	0.053	
2002	4	9	4/9/02	0.051	
2002	4	10	4/10/02	0.045	
2002	4	11	4/11/02	0.043	
2002	4	12	4/12/02	0.039	
2002	4	13	4/13/02	0.039	
2002	4	14	4/14/02	0.035	
2002	4	15	4/15/02	0.039	
2002	4	16	4/16/02	0.035	
2002	4	17	4/17/02	0.036	
2002	4	18	4/18/02	0.032	
2002	4	19	4/19/02	0.030	
2002	4	20	4/20/02	0.027	
2002	4	21	4/21/02	0.026	
2002	4	22	4/22/02	0.023	
2002	4	23	4/23/02	0.024	
2002	4	24	4/24/02	0.031	
2002	4	25	4/25/02	0.022	
2002	4	26	4/26/02	0.026	
2002	4	27	4/27/02	0.022	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2002	4	28	4/28/02	0.019	
2002	4	29	4/29/02	0.017	
2002	4	30	4/30/02	0.018	
2002	5	1	5/1/02	0.017	
2002	5	2	5/2/02	0.015	
2002	5	3	5/3/02	0.015	
2002	5	4	5/4/02	0.015	
2002	5	5	5/5/02	0.015	
2002	5	6	5/6/02	0.015	
2002	5	7	5/7/02	0.017	
2002	5	8	5/8/02	0.013	
2002	5	9	5/9/02	0.012	
2002	5	10	5/10/02	0.012	
2002	5	11	5/11/02	0.011	
2002	5	12	5/12/02	0.009	
2002	5	13	5/13/02	0.007	
2002	5	14	5/14/02	0.009	
2002	5	15	5/15/02	0.010	
2002	5	16	5/16/02	0.010	
2002	5	17	5/17/02	0.009	
2002	5	18	5/18/02	0.010	
2002	5	19	5/19/02	0.009	
2002	5	20	5/20/02	0.007	
2002	5	21	5/21/02	0.007	
2002	5	22	5/22/02	0.006	
2002	5	23	5/23/02	0.006	
2002	5	24	5/24/02	0.006	
2002	5	25	5/25/02	0.007	
2002	5	26	5/26/02	0.006	
2002	5	27	5/27/02	0.006	
2002	5	28	5/28/02	0.005	
2002	5	29	5/29/02	0.005	
2002	5	30	5/30/02	0.005	
2002	5	31	5/31/02	0.004	
2002	6	1	6/1/02	0.005	
2002	6	2	6/2/02	0.004	
2002	6	3	6/3/02	0.004	
2002	6	4	6/4/02	0.004	
2002	6	5	6/5/02	0.004	
2002	6	6	6/6/02	0.003	
2002	6	7	6/7/02	0.003	
2002	6	8	6/8/02	0.003	
2002	6	9	6/9/02	0.004	
2002	6	10	6/10/02	0.004	
2002	6	11	6/11/02	0.003	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2002	6	12	6/12/02	0.003	
2002	6	13	6/13/02	0.003	
2002	6	14	6/14/02	0.002	
2002	6	15	6/15/02	0.002	
2002	6	16	6/16/02	0.002	
2002	6	17	6/17/02	0.002	
2002	6	18	6/18/02	0.002	
2002	6	19	6/19/02	0.002	
2002	6	20	6/20/02	0.002	
2002	6	21	6/21/02	0.002	
2002	6	22	6/22/02	0.002	
2002	6	23	6/23/02	0.002	
2002	6	24	6/24/02	0.002	
2002	6	25	6/25/02	0.002	
2002	6	26	6/26/02	0.002	
2002	6	27	6/27/02	0.001	
2002	6	28	6/28/02	0.001	
2002	6	29	6/29/02	0.001	
2002	6	30	6/30/02	0.001	
2002	7	1	7/1/02	0.001	
2002	7	2	7/2/02	0.001	
2002	7	3	7/3/02	0.001	
2002	7	4	7/4/02	0.001	
2002	7	5	7/5/02	0.001	
2002	7	6	7/6/02	0.001	
2002	7	7	7/7/02	0.001	
2002	7	8	7/8/02	0.001	
2002	7	9	7/9/02	0.001	
2002	7	10	7/10/02	0.001	
2002	7	11	7/11/02	0.001	
2002	7	12	7/12/02	0.001	
2002	7	13	7/13/02	0.001	
2002	7	14	7/14/02	0.001	
2002	7	15	7/15/02	0.001	
2002	7	16	7/16/02	0.001	
2002	7	17	7/17/02	0.001	
2002	7	18	7/18/02	0.001	
2002	7	19	7/19/02	0.001	
2002	7	20	7/20/02	0.001	
2002	7	21	7/21/02	0.001	
2002	7	22	7/22/02	0.001	
2002	7	23	7/23/02	0.000	
2002	7	24	7/24/02	0.000	
2002	7	25	7/25/02	0.000	
2002	7	26	7/26/02	0.000	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2002	7	27	7/27/02	0.000	
2002	7	28	7/28/02	0.000	
2002	7	29	7/29/02	0.000	
2002	7	30	7/30/02	0.000	
2002	7	31	7/31/02	0.000	
2002	8	1	8/1/02	0.000	
2002	8	2	8/2/02	0.000	
2002	8	3	8/3/02	0.000	
2002	8	4	8/4/02	0.000	
2002	8	5	8/5/02	0.000	
2002	8	6	8/6/02	0.000	
2002	8	7	8/7/02	0.000	
2002	8	8	8/8/02	0.000	
2002	8	9	8/9/02	0.000	
2002	8	10	8/10/02	0.000	
2002	8	11	8/11/02	0.000	
2002	8	12	8/12/02	0.000	
2002	8	13	8/13/02	0.000	
2002	8	14	8/14/02	0.000	
2002	8	15	8/15/02	0.000	
2002	8	16	8/16/02	0.000	
2002	8	17	8/17/02	0.000	
2002	8	18	8/18/02	0.000	
2002	8	19	8/19/02	0.000	
2002	8	20	8/20/02	0.000	
2002	8	21	8/21/02	0.000	
2002	8	22	8/22/02	0.000	
2002	8	23	8/23/02	0.000	
2002	8	24	8/24/02	0.000	
2002	8	25	8/25/02	0.000	
2002	8	26	8/26/02	0.000	
2002	8	27	8/27/02	0.000	
2002	8	28	8/28/02	0.000	
2002	8	29	8/29/02	0.000	
2002	8	30	8/30/02	0.000	
2002	8	31	8/31/02	0.000	
2002	9	1	9/1/02	0.000	
2002	9	2	9/2/02	0.000	
2002	9	3	9/3/02	0.000	
2002	9	4	9/4/02	0.000	
2002	9	5	9/5/02	0.000	
2002	9	6	9/6/02	2.065	
2002	9	7	9/7/02	23.162	
2002	9	8	9/8/02	0.069	
2002	9	9	9/9/02	0.062	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2002	9	10	9/10/02	0.055	
2002	9	11	9/11/02	0.057	
2002	9	12	9/12/02	0.054	
2002	9	13	9/13/02	0.048	
2002	9	14	9/14/02	0.046	
2002	9	15	9/15/02	0.044	
2002	9	16	9/16/02	0.045	
2002	9	17	9/17/02	0.044	
2002	9	18	9/18/02	0.045	
2002	9	19	9/19/02	0.037	
2002	9	20	9/20/02	0.038	
2002	9	21	9/21/02	0.037	
2002	9	22	9/22/02	0.033	
2002	9	23	9/23/02	0.031	
2002	9	24	9/24/02	0.030	
2002	9	25	9/25/02	0.031	
2002	9	26	9/26/02	0.029	
2002	9	27	9/27/02	0.030	
2002	9	28	9/28/02	0.033	
2002	9	29	9/29/02	0.030	
2002	9	30	9/30/02	0.028	
2002	10	1	10/1/02	0.027	
2002	10	2	10/2/02	0.023	
2002	10	3	10/3/02	0.022	
2002	10	4	10/4/02	0.021	
2002	10	5	10/5/02	0.019	
2002	10	6	10/6/02	0.019	
2002	10	7	10/7/02	0.017	
2002	10	8	10/8/02	0.018	
2002	10	9	10/9/02	0.017	
2002	10	10	10/10/02	0.017	
2002	10	11	10/11/02	0.017	
2002	10	12	10/12/02	0.019	
2002	10	13	10/13/02	0.015	
2002	10	14	10/14/02	0.016	
2002	10	15	10/15/02	0.016	
2002	10	16	10/16/02	0.016	
2002	10	17	10/17/02	0.016	
2002	10	18	10/18/02	0.015	
2002	10	19	10/19/02	0.014	
2002	10	20	10/20/02	0.012	
2002	10	21	10/21/02	0.013	
2002	10	22	10/22/02	0.012	
2002	10	23	10/23/02	0.011	
2002	10	24	10/24/02	0.011	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2002	10	25	10/25/02	0.011	
2002	10	26	10/26/02	0.010	
2002	10	27	10/27/02	0.009	
2002	10	28	10/28/02	0.009	
2002	10	29	10/29/02	0.009	
2002	10	30	10/30/02	0.008	
2002	10	31	10/31/02	0.008	
2002	11	1	11/1/02	0.008	0
2002	11	2	11/2/02	0.007	0
2002	11	3	11/3/02	0.006	0
2002	11	4	11/4/02	0.007	0
2002	11	5	11/5/02	0.006	0
2002	11	6	11/6/02	0.006	0
2002	11	7	11/7/02	0.006	0
2002	11	8	11/8/02	3.241	35
2002	11	9	11/9/02	8.193	43
2002	11	10	11/10/02	0.967	13
2002	11	11	11/11/02	0.048	
2002	11	12	11/12/02	0.017	
2002	11	13	11/13/02	0.035	
2002	11	14	11/14/02	0.032	
2002	11	15	11/15/02	0.010	
2002	11	16	11/16/02	0.010	
2002	11	17	11/17/02	0.030	
2002	11	18	11/18/02	0.021	
2002	11	19	11/19/02	0.019	
2002	11	20	11/20/02	0.014	
2002	11	21	11/21/02	0.011	
2002	11	22	11/22/02	0.023	
2002	11	23	11/23/02	0.026	
2002	11	24	11/24/02	0.024	
2002	11	25	11/25/02	0.016	
2002	11	26	11/26/02	0.013	
2002	11	27	11/27/02	0.009	
2002	11	28	11/28/02	0.009	
2002	11	29	11/29/02	0.020	
2002	11	30	11/30/02	0.018	
2002	12	1	12/1/02	0.019	
2002	12	2	12/2/02	0.017	
2002	12	3	12/3/02	0.017	
2002	12	4	12/4/02	0.015	
2002	12	5	12/5/02	0.014	
2002	12	6	12/6/02	0.013	
2002	12	7	12/7/02	0.014	
2002	12	8	12/8/02	0.013	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2002	12	9	12/9/02	0.013	
2002	12	10	12/10/02	0.013	
2002	12	11	12/11/02	0.012	
2002	12	12	12/12/02	0.011	
2002	12	13	12/13/02	0.011	0
2002	12	14	12/14/02	0.011	0
2002	12	15	12/15/02	0.010	0
2002	12	16	12/16/02	0.010	30
2002	12	17	12/17/02	0.010	0
2002	12	18	12/18/02	0.009	0
2002	12	19	12/19/02	0.008	5
2002	12	20	12/20/02	0.010	0
2002	12	21	12/21/02	0.009	0
2002	12	22	12/22/02	0.008	0
2002	12	23	12/23/02	0.007	0
2002	12	24	12/24/02	0.008	0
2002	12	25	12/25/02	0.007	0
2002	12	26	12/26/02	0.007	0
2002	12	27	12/27/02	0.006	0
2002	12	28	12/28/02	0.006	0
2002	12	29	12/29/02	0.006	0
2002	12	30	12/30/02	0.006	0
2002	12	31	12/31/02	0.005	0
2003	1	1	1/1/03	0.004	0
2003	1	2	1/2/03	0.004	0
2003	1	3	1/3/03	0.004	0
2003	1	4	1/4/03	0.004	0
2003	1	5	1/5/03	0.004	0
2003	1	6	1/6/03	0.003	0
2003	1	7	1/7/03	0.003	0
2003	1	8	1/8/03	0.003	0
2003	1	9	1/9/03	0.003	0
2003	1	10	1/10/03	0.003	0
2003	1	11	1/11/03	0.003	
2003	1	12	1/12/03	0.003	
2003	1	13	1/13/03	0.003	
2003	1	14	1/14/03	0.002	
2003	1	15	1/15/03	0.002	
2003	1	16	1/16/03	0.002	
2003	1	17	1/17/03	0.002	
2003	1	18	1/18/03	0.002	
2003	1	19	1/19/03	0.002	
2003	1	20	1/20/03	0.002	
2003	1	21	1/21/03	0.002	
2003	1	22	1/22/03	0.002	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2003	1	23	1/23/03	0.001	
2003	1	24	1/24/03	0.001	
2003	1	25	1/25/03	0.001	
2003	1	26	1/26/03	0.001	
2003	1	27	1/27/03	0.001	
2003	1	28	1/28/03	0.001	
2003	1	29	1/29/03	0.001	
2003	1	30	1/30/03	0.001	
2003	1	31	1/31/03	0.001	
2003	2	1	2/1/03	0.001	
2003	2	2	2/2/03	0.001	
2003	2	3	2/3/03	0.001	
2003	2	4	2/4/03	0.001	
2003	2	5	2/5/03	0.001	
2003	2	6	2/6/03	0.001	
2003	2	7	2/7/03	0.001	0
2003	2	8	2/8/03	0.001	
2003	2	9	2/9/03	0.001	
2003	2	10	2/10/03	0.001	
2003	2	11	2/11/03	50.308	59
2003	2	12	2/12/03	153.553	
2003	2	13	2/13/03	116.327	
2003	2	14	2/14/03	55.564	
2003	2	15	2/15/03	2.439	
2003	2	16	2/16/03	2.031	
2003	2	17	2/17/03	1.739	
2003	2	18	2/18/03	1.538	
2003	2	19	2/19/03	1.410	
2003	2	20	2/20/03	1.244	
2003	2	21	2/21/03	1.120	
2003	2	22	2/22/03	1.042	
2003	2	23	2/23/03	0.943	
2003	2	24	2/24/03	0.866	0
2003	2	25	2/25/03	190.710	132
2003	2	26	2/26/03	28.383	13
2003	2	27	2/27/03	31.744	86
2003	2	28	2/28/03	8.011	31
2003	3	1	3/1/03	5.550	0
2003	3	2	3/2/03	4.193	10
2003	3	3	3/3/03	3.367	2
2003	3	4	3/4/03	2.781	31
2003	3	5	3/5/03	2.912	45
2003	3	6	3/6/03	2.097	5
2003	3	7	3/7/03	1.839	12
2003	3	8	3/8/03	1.629	20

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2003	3	9	3/9/03	1.481	17
2003	3	10	3/10/03	1.373	12
2003	3	11	3/11/03	1.279	8
2003	3	12	3/12/03	1.164	8
2003	3	13	3/13/03	1.088	18
2003	3	14	3/14/03	1.018	10
2003	3	15	3/15/03	96.332	
2003	3	16	3/16/03	51.539	
2003	3	17	3/17/03	5.526	
2003	3	18	3/18/03	4.174	
2003	3	19	3/19/03	3.297	
2003	3	20	3/20/03	2.713	
2003	3	21	3/21/03	2.300	
2003	3	22	3/22/03	1.996	
2003	3	23	3/23/03	1.824	
2003	3	24	3/24/03	1.650	
2003	3	25	3/25/03	1.493	
2003	3	26	3/26/03	1.389	
2003	3	27	3/27/03	1.301	
2003	3	28	3/28/03	1.188	
2003	3	29	3/29/03	1.114	
2003	3	30	3/30/03	1.040	
2003	3	31	3/31/03	1.141	
2003	4	1	4/1/03	0.974	
2003	4	2	4/2/03	0.920	
2003	4	3	4/3/03	0.886	
2003	4	4	4/4/03	0.849	
2003	4	5	4/5/03	0.805	
2003	4	6	4/6/03	0.765	
2003	4	7	4/7/03	0.705	
2003	4	8	4/8/03	0.636	
2003	4	9	4/9/03	0.612	
2003	4	10	4/10/03	0.603	
2003	4	11	4/11/03	0.567	
2003	4	12	4/12/03	0.523	
2003	4	13	4/13/03	0.504	
2003	4	14	4/14/03	127.782	
2003	4	15	4/15/03	6.659	
2003	4	16	4/16/03	1.486	
2003	4	17	4/17/03	23.888	
2003	4	18	4/18/03	1.572	
2003	4	19	4/19/03	1.378	
2003	4	20	4/20/03	1.250	
2003	4	21	4/21/03	1.163	
2003	4	22	4/22/03	1.095	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2003	4	23	4/23/03	1.018	
2003	4	24	4/24/03	0.941	
2003	4	25	4/25/03	0.882	
2003	4	26	4/26/03	0.836	
2003	4	27	4/27/03	0.793	
2003	4	28	4/28/03	0.738	
2003	4	29	4/29/03	0.704	
2003	4	30	4/30/03	0.799	
2003	5	1	5/1/03	0.639	
2003	5	2	5/2/03	0.601	
2003	5	3	5/3/03	21.329	
2003	5	4	5/4/03	0.717	
2003	5	5	5/5/03	0.634	
2003	5	6	5/6/03	0.602	
2003	5	7	5/7/03	0.564	
2003	5	8	5/8/03	0.534	
2003	5	9	5/9/03	0.506	
2003	5	10	5/10/03	0.479	
2003	5	11	5/11/03	0.442	
2003	5	12	5/12/03	0.416	
2003	5	13	5/13/03	0.390	
2003	5	14	5/14/03	0.378	
2003	5	15	5/15/03	0.360	
2003	5	16	5/16/03	0.338	
2003	5	17	5/17/03	0.322	
2003	5	18	5/18/03	0.306	
2003	5	19	5/19/03	0.289	
2003	5	20	5/20/03	0.272	
2003	5	21	5/21/03	0.255	
2003	5	22	5/22/03	0.245	
2003	5	23	5/23/03	0.236	
2003	5	24	5/24/03	0.225	
2003	5	25	5/25/03	0.212	
2003	5	26	5/26/03	0.201	
2003	5	27	5/27/03	0.189	
2003	5	28	5/28/03	0.179	
2003	5	29	5/29/03	0.172	
2003	5	30	5/30/03	0.164	
2003	5	31	5/31/03	0.197	
2003	6	1	6/1/03	0.152	
2003	6	2	6/2/03	0.145	
2003	6	3	6/3/03	0.136	
2003	6	4	6/4/03	0.129	
2003	6	5	6/5/03	0.122	
2003	6	6	6/6/03	0.116	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2003	6	7	6/7/03	0.110	
2003	6	8	6/8/03	0.104	
2003	6	9	6/9/03	0.099	
2003	6	10	6/10/03	0.090	
2003	6	11	6/11/03	0.085	
2003	6	12	6/12/03	0.080	
2003	6	13	6/13/03	0.075	
2003	6	14	6/14/03	0.070	
2003	6	15	6/15/03	0.066	
2003	6	16	6/16/03	0.061	
2003	6	17	6/17/03	0.057	
2003	6	18	6/18/03	0.053	
2003	6	19	6/19/03	0.050	
2003	6	20	6/20/03	0.046	
2003	6	21	6/21/03	0.042	
2003	6	22	6/22/03	0.039	
2003	6	23	6/23/03	0.035	
2003	6	24	6/24/03	0.032	
2003	6	25	6/25/03	0.028	
2003	6	26	6/26/03	0.025	
2003	6	27	6/27/03	0.021	
2003	6	28	6/28/03	0.018	
2003	6	29	6/29/03	0.014	
2003	6	30	6/30/03	0.012	
2003	7	1	7/1/03	0.010	
2003	7	2	7/2/03	0.009	
2003	7	3	7/3/03	0.008	
2003	7	4	7/4/03	0.008	
2003	7	5	7/5/03	0.007	
2003	7	6	7/6/03	0.007	
2003	7	7	7/7/03	0.007	
2003	7	8	7/8/03	0.007	
2003	7	9	7/9/03	0.006	
2003	7	10	7/10/03	0.007	
2003	7	11	7/11/03	0.007	
2003	7	12	7/12/03	0.007	
2003	7	13	7/13/03	0.006	
2003	7	14	7/14/03	0.006	
2003	7	15	7/15/03	0.006	
2003	7	16	7/16/03	0.006	
2003	7	17	7/17/03	0.005	
2003	7	18	7/18/03	0.005	
2003	7	19	7/19/03	0.005	
2003	7	20	7/20/03	0.005	
2003	7	21	7/21/03	0.004	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2003	7	22	7/22/03	0.004	
2003	7	23	7/23/03	0.004	
2003	7	24	7/24/03	0.004	
2003	7	25	7/25/03	0.004	
2003	7	26	7/26/03	0.004	
2003	7	27	7/27/03	0.003	
2003	7	28	7/28/03	0.003	
2003	7	29	7/29/03	0.003	
2003	7	30	7/30/03	0.003	
2003	7	31	7/31/03	0.003	
2003	8	1	8/1/03	0.003	
2003	8	2	8/2/03	0.003	
2003	8	3	8/3/03	0.003	
2003	8	4	8/4/03	0.002	
2003	8	5	8/5/03	0.002	
2003	8	6	8/6/03	0.002	
2003	8	7	8/7/03	0.002	
2003	8	8	8/8/03	0.002	
2003	8	9	8/9/03	0.002	
2003	8	10	8/10/03	0.002	
2003	8	11	8/11/03	0.002	
2003	8	12	8/12/03	0.002	
2003	8	13	8/13/03	0.002	
2003	8	14	8/14/03	0.002	
2003	8	15	8/15/03	0.002	
2003	8	16	8/16/03	0.001	
2003	8	17	8/17/03	0.001	
2003	8	18	8/18/03	0.001	
2003	8	19	8/19/03	0.001	
2003	8	20	8/20/03	0.001	
2003	8	21	8/21/03	0.001	
2003	8	22	8/22/03	0.001	
2003	8	23	8/23/03	0.001	
2003	8	24	8/24/03	0.001	
2003	8	25	8/25/03	0.001	
2003	8	26	8/26/03	0.001	
2003	8	27	8/27/03	0.001	
2003	8	28	8/28/03	0.001	
2003	8	29	8/29/03	0.001	
2003	8	30	8/30/03	0.001	
2003	8	31	8/31/03	0.001	
2003	9	1	9/1/03	0.001	
2003	9	2	9/2/03	0.001	
2003	9	3	9/3/03	0.001	
2003	9	4	9/4/03	0.001	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2003	9	5	9/5/03	0.001	
2003	9	6	9/6/03	0.001	
2003	9	7	9/7/03	0.001	
2003	9	8	9/8/03	0.001	
2003	9	9	9/9/03	0.001	
2003	9	10	9/10/03	0.001	
2003	9	11	9/11/03	0.000	
2003	9	12	9/12/03	0.000	
2003	9	13	9/13/03	0.000	
2003	9	14	9/14/03	0.000	
2003	9	15	9/15/03	0.000	
2003	9	16	9/16/03	0.000	
2003	9	17	9/17/03	0.000	
2003	9	18	9/18/03	0.000	
2003	9	19	9/19/03	0.000	
2003	9	20	9/20/03	0.000	
2003	9	21	9/21/03	0.000	
2003	9	22	9/22/03	0.000	
2003	9	23	9/23/03	0.000	
2003	9	24	9/24/03	0.000	
2003	9	25	9/25/03	0.000	
2003	9	26	9/26/03	0.000	
2003	9	27	9/27/03	0.000	
2003	9	28	9/28/03	0.000	
2003	9	29	9/29/03	0.000	
2003	9	30	9/30/03	0.000	
2003	10	1	10/1/03	0.000	
2003	10	2	10/2/03	0.000	
2003	10	3	10/3/03	0.000	
2003	10	4	10/4/03	0.000	
2003	10	5	10/5/03	0.000	
2003	10	6	10/6/03	0.000	
2003	10	7	10/7/03	0.000	
2003	10	8	10/8/03	0.000	
2003	10	9	10/9/03	0.000	
2003	10	10	10/10/03	0.000	
2003	10	11	10/11/03	0.000	
2003	10	12	10/12/03	0.000	
2003	10	13	10/13/03	0.000	
2003	10	14	10/14/03	0.000	
2003	10	15	10/15/03	0.000	
2003	10	16	10/16/03	0.000	
2003	10	17	10/17/03	0.000	
2003	10	18	10/18/03	0.000	
2003	10	19	10/19/03	0.000	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2003	10	20	10/20/03	0.000	
2003	10	21	10/21/03	0.000	
2003	10	22	10/22/03	0.000	
2003	10	23	10/23/03	0.000	
2003	10	24	10/24/03	0.000	
2003	10	25	10/25/03	0.000	
2003	10	26	10/26/03	0.000	
2003	10	27	10/27/03	0.000	
2003	10	28	10/28/03	0.000	
2003	10	29	10/29/03	0.000	
2003	10	30	10/30/03	0.000	
2003	10	31	10/31/03	0.000	
2003	11	1	11/1/03	0.000	
2003	11	2	11/2/03	0.000	
2003	11	3	11/3/03	0.000	
2003	11	4	11/4/03	0.000	
2003	11	5	11/5/03	0.000	
2003	11	6	11/6/03	0.000	
2003	11	7	11/7/03	0.000	
2003	11	8	11/8/03	0.000	
2003	11	9	11/9/03	0.000	
2003	11	10	11/10/03	0.000	
2003	11	11	11/11/03	0.000	
2003	11	12	11/12/03	15.002	
2003	11	13	11/13/03	0.056	
2003	11	14	11/14/03	0.047	
2003	11	15	11/15/03	0.039	
2003	11	16	11/16/03	0.038	
2003	11	17	11/17/03	0.036	
2003	11	18	11/18/03	0.035	
2003	11	19	11/19/03	0.033	
2003	11	20	11/20/03	0.033	
2003	11	21	11/21/03	0.031	
2003	11	22	11/22/03	0.030	
2003	11	23	11/23/03	0.030	
2003	11	24	11/24/03	0.029	
2003	11	25	11/25/03	0.028	
2003	11	26	11/26/03	0.026	
2003	11	27	11/27/03	0.025	
2003	11	28	11/28/03	0.026	
2003	11	29	11/29/03	0.025	
2003	11	30	11/30/03	0.024	
2003	12	1	12/1/03	0.023	
2003	12	2	12/2/03	0.022	
2003	12	3	12/3/03	0.021	

Year	Month	Day	Date	Model Daily Average Flow	Measured Daily Average Flow
Units				cfs	cfs
2003	12	4	12/4/03	0.020	
2003	12	5	12/5/03	0.019	
2003	12	6	12/6/03	0.019	
2003	12	7	12/7/03	0.018	
2003	12	8	12/8/03	0.017	
2003	12	9	12/9/03	0.016	
2003	12	10	12/10/03	0.016	
2003	12	11	12/11/03	0.015	
2003	12	12	12/12/03	0.014	
2003	12	13	12/13/03	0.014	
2003	12	14	12/14/03	0.013	
2003	12	15	12/15/03	0.013	
2003	12	16	12/16/03	0.012	
2003	12	17	12/17/03	0.012	
2003	12	18	12/18/03	0.011	
2003	12	19	12/19/03	0.011	
2003	12	20	12/20/03	0.010	
2003	12	21	12/21/03	0.010	
2003	12	22	12/22/03	0.009	
2003	12	23	12/23/03	0.009	
2003	12	24	12/24/03	0.278	
2003	12	25	12/25/03	43.532	
2003	12	26	12/26/03	0.878	
2003	12	27	12/27/03	0.154	
2003	12	28	12/28/03	0.146	
2003	12	29	12/29/03	0.139	
2003	12	30	12/30/03	0.133	

Table F-2. Modeled Flow vs Measured Flows

Date	Model Daily Average Flow -cfs	Observed Daily Average Flow -cfs	Percent Difference -%, difference of observed from model over observed	Actual Difference -cfs, observed from model
11/29/01	2.801	18	-84.4%	-15.20
2/17/02	7.614	3	153.8%	4.61
3/7/02	0.023	7	-99.7%	-6.98
11/8/02	3.241	35	-90.7%	-31.76
11/9/02	8.193	43	-80.9%	-34.81
11/10/02	0.967	13	-92.6%	-12.03
12/16/02	0.010	30	-99.97%	-29.99
12/19/02	0.008	5	-99.8%	-4.99
2/11/03	50.308	59	-14.7%	-8.69
2/25/03	190.710	132	44.5%	58.71
2/26/03	28.383	13	118.3%	15.38
2/27/03	31.744	86	-63.1%	-54.26
2/28/03	8.011	31	-74.2%	-22.99
3/2/03	4.193	10	-58.1%	-5.81
3/3/03	3.367	2	68.4%	1.37
3/4/03	2.781	31	-91.0%	-28.22
3/5/03	2.912	45	-93.5%	-42.09
3/6/03	2.097	5	-58.1%	-2.90
3/7/03	1.839	12	-84.7%	-10.16
3/8/03	1.629	20	-91.9%	-18.37
3/9/03	1.481	17	-91.3%	-15.52
3/10/03	1.373	12	-88.6%	-10.63
3/11/03	1.279	8	-84.0%	-6.72
3/12/03	1.164	8	-85.5%	-6.84
3/13/03	1.088	18	-94.0%	-16.91
3/14/03	1.018	10	-89.8%	-8.98

Table F-3. Modeled Volume vs. Measured Volume

Date	Changing Model Values to Daily Volume, cf	Changing Observed Values to Daily Volume, cf
11/29/01	241996	1555200
2/17/02	657867	259200
3/7/02	1982	604800
11/8/02	280035	3024000
11/9/02	707867	3715200
11/10/02	83510	1123200
12/16/02	904	2592000
12/19/02	715	432000
2/11/03	4346577	5097600
2/25/03	16477344	11404800
2/26/03	2452326	1123200
2/27/03	2742682	7430400
2/28/03	692118	2678400
3/2/03	362239	864000
3/3/03	290940	172800
3/4/03	240244	2678400
3/5/03	251590	3888000
3/6/03	181142	432000
3/7/03	158903	1036800
3/8/03	140781	1728000
3/9/03	127993	1468800
3/10/03	118657	1036800
3/11/03	110532	691200
3/12/03	100566	691200
3/13/03	94005	1555200
3/14/03	87948	864000

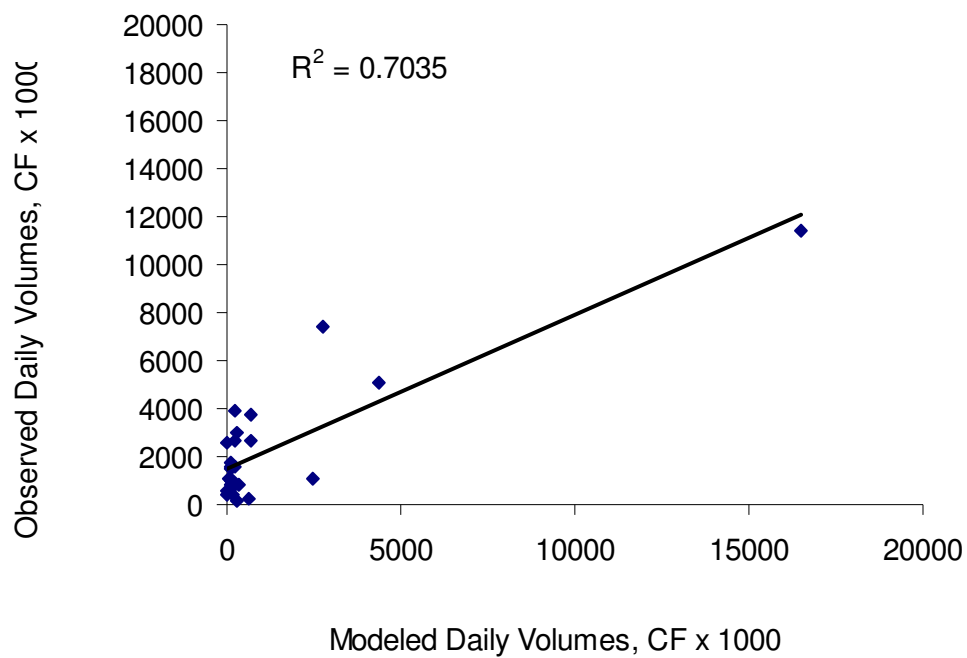


Figure F-1. Measured Daily Volumes vs Modeled Daily Volumes

Table F-4. Modeled Total Volume vs Measured Total Volume

Total Modeled Volumes for 26 days, L	Total Observed Volumes for 26 days, L	Percent Difference -%, difference of observed from model over observed	Actual Difference -L, observed from model
876421612	1646496115	47%	-770074503

Table F-5. Comparison of Modeled and Measured Flows

Statistics of Directly Comparable Model Values to Observed Values Above CFS of 2.28 (26 Values)		Statistics of Observed Values Above CFS of 2.28 (26 Values)	
Mean	14	Mean	26
Median	2	Median	15
25th	1	25th	9
75th	7	75th	31
STDEV	38	STDEV	29
Statistics of Percent Differences		Statistics of Actual Differences	
Mean	-55%	Mean	-12
Median	-85%	Median	-10
25th	-92%	25th	-22
75th	-59%	75th	-6
STDEV	0.70	STDEV	21

Table F-6. Modeled Water Quality, All Values.

Number	Date	Flow	Total Copper	Total Lead	Total Zinc
			µg/L	µg/L	µg/L
19004	2/17/94	80.6874	14	14	78
19004	3/24/94	77.9417	6	6	35
19004	4/24/94	15.4465	32	34	175
19004	11/10/94	14.4909	24	24	134
19004	1/11/95	47.9248	5	5	30
19004	2/14/95	285.361	31	31	173
19004	4/16/95	47.6048	32	32	176
19004	11/1/95	24.6359	74	76	408
19004	12/9/96	10.7718	19	18	106
19004	1/16/97	1.78252	1	0	4
19004	12/6/97	51.7472	53	53	294
19004	3/14/98	2.98883	0	0	0
19004	11/8/98	28.7118	41	42	228
19004	1/25/99	88.7292	42	43	231
19004	3/15/99	8.14882	39	39	216
19004	2/12/00	45.11	43	44	237
19004	2/21/00	216.509	22	22	121
19004	3/5/00	79.8623	24	24	134
19004	4/17/00	41.7563	21	22	118
19004	10/27/00	37.9718	28	28	157
19004	1/8/01	28.0362	26	26	142
19004	2/13/01	54.4753	50	50	280
19004	11/12/01	10.5909	17	18	95
19004	11/29/01	2.80088	32	32	175
19004	2/17/02	7.6142	53	54	293
19004	11/8/02	3.24115	33	34	183

19004	2/11/03	50.3076	38	38	206
19004	2/25/03	190.71	23	23	129
19006	2/12/00	13.2766	63	74	316
19006	2/21/00	63.4845	25	28	128
19006	1/8/01	8.38546	31	36	157
19006	2/13/01	16.4391	57	64	293
19006	11/12/01	3.47155	17	20	89
19014	1/8/01	0.866875	27	32	151
19014	2/13/01	1.68843	51	59	292
19014	11/12/01	0.362798	12	14	69
19016	2/12/00	7.75739	33	33	181
19016	2/21/00	37.1424	17	16	93
19016	1/8/01	4.87796	17	17	96
19016	2/13/01	9.55507	38	36	212
19016	11/12/01	1.94136	11	10	58
19018	1/8/01	11.6857	22	19	125
19018	2/13/01	22.7255	46	40	267
19018	11/12/01	4.22921	16	14	91
19024	2/12/00	30.7277	40	38	221
19024	2/21/00	150.342	21	20	120
19024	1/8/01	18.9028	28	26	154
19024	2/13/01	37.2259	50	47	282
19024	11/12/01	7.10023	18	17	102
19026	1/8/01	14.8463	25	23	140
19026	2/13/01	29.3028	48	44	275
19026	11/12/01	5.99581	16	15	91
19028	2/12/00	9.20883	60	60	332
19028	2/21/00	44.0897	28	27	159
19028	1/8/01	5.8327	31	30	169
19028	2/13/01	11.6731	60	56	334
19028	11/12/01	2.49796	15	15	85
19035	2/12/00	2.48031	20	18	110
19035	2/21/00	11.9094	11	10	64
19035	1/8/01	1.57353	10	9	58
19035	2/13/01	3.18453	24	22	134
19035	11/12/01	0.668691	6	6	35

Table F-7. Observed Water Quality, All Values.

Subwatershed Number	Date	Total Copper	Total Lead	Total Zinc
		µg/L	µg/L	µg/L
19004	2/17/94	34	110	260
19004	3/24/94	29	140	240
19004	4/24/94	44	70	320
19004	11/10/94	36	35	180
19004	1/11/95	17	44	150
19004	2/14/95	40	110	360
19004	4/16/95	85	140	560
19004	11/1/95	46	23	25

Subwatershed Number	Date	Total Copper	Total Lead	Total Zinc
		µg/L	µg/L	µg/L
19004	12/9/96	20	16	70
19004	1/16/97	10	58	200
19004	12/6/97	28	42	110
19004	3/14/98	28	95	92
19004	11/8/98	6	1	30
19004	1/25/99	5	7	48
19004	3/15/99	15	82	210
19004	2/12/00	29	15	96
19004	2/21/00	16	1	50
19004	3/5/00	16	1	50
19004	4/17/00	14	5	80
19004	10/27/00	27	22	150
19004	1/8/01	57	69	255
19004	2/13/01	16	25	110
19004	11/12/01	97	94	740
19004	11/29/01	27	28	162
19004	2/17/02	53	32	314
19004	11/8/02	28	17	118
19004	2/11/03	33	29	230
19004	2/25/03	16	23	154
19006	2/12/00	68	34	160
19006	2/21/00	23	23	180
19006	1/8/01	52	91	420
19006	2/13/01	16	29	100
19006	11/12/01	49	39	370
19014	1/8/01	36	21	230
19014	2/13/01	19	18	110
19014	11/12/01	37	12	200
19016	2/12/00	68	52	300
19016	2/21/00	19	19	160
19016	1/8/01	65	90	480
19016	2/13/01	15	21	110
19016	11/12/01	45	52	300
19018	1/8/01	70	68	660
19018	2/13/01	38	53	280
19018	11/12/01	42	29	340
19024	2/12/00	33	83	327
19024	2/21/00	19	26	81
19024	1/8/01	56	59	360
19024	2/13/01	41	61	280
19024	11/12/01	32	19	180
19026	1/8/01	32	27	190
19026	2/13/01	17	23	120
19026	11/12/01	170	270	1400
19028	2/12/00	43	76	370
19028	2/21/00	27	35	10

Subwatershed Number	Date	Total Copper	Total Lead	Total Zinc
		µg/L	µg/L	µg/L
19028	1/8/01	37	29	260
19028	2/13/01	33	59	270
19028	11/12/01	180	170	1900
19035	2/12/00	23	16	100
19035	2/21/00	10	10	54
19035	1/8/01	32	19	160
19035	2/13/01	10	9	55
19035	11/12/01	49	36	290

Table F-8. Percent Differences for Water Qualities with Flows Over 2.28 cfs.

Subwatershed Number	Date	Total Copper	Total Lead	Total Zinc
		%	%	%
19004	2/17/94	-59%	-87%	-70%
19004	3/24/94	-78%	-95%	-85%
19004	4/24/94	-27%	-51%	-45%
19004	11/10/94	-33%	-32%	-25%
19004	1/11/95	-68%	-88%	-80%
19004	2/14/95	-22%	-72%	-52%
19004	4/16/95	-63%	-77%	-69%
19004	11/1/95	62%	231%	1534%
19004	12/9/96	-6%	15%	51%
19004	12/6/97	89%	26%	167%
19004	3/14/98	-100%	-100%	-100%
19004	11/8/98	591%	4097%	660%
19004	1/25/99	741%	513%	381%
19004	3/15/99	161%	-52%	3%
19004	2/12/00	49%	195%	147%
19004	2/21/00	37%	2105%	142%
19004	3/5/00	50%	2292%	168%
19004	4/17/00	53%	335%	47%
19004	10/27/00	5%	28%	4%
19004	1/8/01	-54%	-62%	-44%
19004	2/13/01	215%	106%	154%
19004	11/12/01	-82%	-81%	-87%
19004	11/29/01	18%	14%	8%
19004	2/17/02	1%	68%	-7%
19004	11/8/02	19%	99%	55%
19004	2/11/03	14%	32%	-10%
19004	2/25/03	45%	1%	-16%
19006	2/12/00	-8%	116%	97%
19006	2/21/00	8%	22%	-29%
19006	1/8/01	-40%	-61%	-63%
19006	2/13/01	255%	119%	193%
19006	11/12/01	-64%	-49%	-76%
19016	2/12/00	-51%	-37%	-40%

19016	2/21/00	-10%	-14%	-42%
19016	1/8/01	-73%	-81%	-80%
19016	2/13/01	156%	73%	93%
19018	1/8/01	-69%	-73%	-81%
19018	2/13/01	21%	-25%	-5%
19018	11/12/01	-63%	-53%	-73%
19024	2/12/00	20%	-54%	-32%
19024	2/21/00	12%	-23%	49%
19024	1/8/01	-51%	-56%	-57%
19024	2/13/01	22%	-24%	1%
19024	11/12/01	-43%	-10%	-43%
19026	1/8/01	-23%	-14%	-26%
19026	2/13/01	183%	92%	129%
19026	11/12/01	-91%	-95%	-94%
19028	2/12/00	41%	-21%	-10%
19028	2/21/00	5%	-24%	1489%
19028	1/8/01	-17%	4%	-35%
19028	2/13/01	81%	-5%	24%
19028	11/12/01	-91%	-91%	-96%
19035	2/12/00	-14%	12%	10%
19035	2/21/00	15%	4%	19%
19035	2/13/01	141%	143%	145%

Table F-9. Actual Differences for Water Qualities with Flows Over 2.28 cfs.

Subwatershed Number	Date	Total Copper	Total Lead	Total Zinc
		µg/L	µg/L	µg/L
19004	2/17/94	-20	-96	-182
19004	3/24/94	-23	-134	-205
19004	4/24/94	-12	-36	-145
19004	11/10/94	-12	-11	-46
19004	1/11/95	-12	-39	-120
19004	2/14/95	-9	-79	-187
19004	4/16/95	-53	-108	-384
19004	11/1/95	28	53	383
19004	12/9/96	-1	2	36
19004	12/6/97	25	11	184
19004	3/14/98	-28	-95	-92
19004	11/8/98	35	41	198
19004	1/25/99	37	36	183
19004	3/15/99	24	-43	6
19004	2/12/00	14	29	141
19004	2/21/00	6	21	71
19004	3/5/00	8	23	84
19004	4/17/00	7	17	38
19004	10/27/00	1	6	7
19004	1/8/01	-31	-43	-113
19004	2/13/01	34	26	170

19004	11/12/01	-80	-76	-645
19004	11/29/01	5	4	13
19004	2/17/02	0	22	-21
19004	11/8/02	5	17	65
19004	2/11/03	5	9	-24
19004	2/25/03	7	0	-25
19006	2/12/00	-5	40	156
19006	2/21/00	2	5	-52
19006	1/8/01	-21	-55	-263
19006	2/13/01	41	35	193
19006	11/12/01	-32	-19	-281
19016	2/12/00	-35	-19	-119
19016	2/21/00	-2	-3	-67
19016	1/8/01	-48	-73	-384
19016	2/13/01	23	15	102
19018	1/8/01	-48	-49	-535
19018	2/13/01	8	-13	-13
19018	11/12/01	-26	-15	-249
19024	2/12/00	7	-45	-106
19024	2/21/00	2	-6	39
19024	1/8/01	-28	-33	-206
19024	2/13/01	9	-14	2
19024	11/12/01	-14	-2	-78
19026	1/8/01	-7	-4	-50
19026	2/13/01	31	21	155
19026	11/12/01	-154	-255	-1309
19028	2/12/00	17	-16	-38
19028	2/21/00	1	-8	149
19028	1/8/01	-6	1	-91
19028	2/13/01	27	-3	64
19028	11/12/01	-165	-155	-1815
19035	2/12/00	-3	2	10
19035	2/21/00	1	0	10
19035	2/13/01	14	13	79

Table F-10. Water Quality Statistical Summary of Modeled and Observed Data Sets and Percent and Actual Differences.

Statistics of Modeled Values (55 values)	Copper - ug/L	Lead -ug/L	Zinc -ug/L	Statistics of Modeled Values that directly compared to Observed Values (55 values)	Copper -ug/L	Lead -ug/L	Zinc -ug/L
Mean	31	31	170	Mean	39	51	270
Median	28	28	157	Median	32	32	180
25th	19	18	100	25th	18	22	100
75th	40	45	317	75th	45	70	320
Statistics of Percent Differences (55 Values)	Copper -%	Lead -%	Zinc -%	Statistics of Actual Differences (55 Values)	Copper -ug/L	Lead -ug/L	Zinc -ug/L
Mean	33%	166%	76%	Mean	-8.1	-20.0	-96.5
Median	5%	-14%	-10%	Median	1.3	-3.1	-23.9
25th	-51%	-55%	-55%	25th	-21	-41	-132
75th	47%	71%	74%	75th	8.5	14.1	68.0

Table F-11. Calculated Loads for Modeled and Observed Values.

Sub watershed Number	Date	Flow Volume	Total Copper	Total Lead	Total Zinc	Total Copper	Total Lead	Total Zinc
			Modeled	Modeled	Modeled	Observed	Observed	Observed
Units		L	g	g	g	g	g	g
19004	11/29/01	6,852,360	217	219	1197	185	192	1110
19004	2/17/02	18,628,159	992	1003	5452	987	596	5849
19004	11/8/02	7,929,481	264	268	1451	222	135	936
19004	2/11/03	123,077,664	4629	4724	25361	4062	3569	28308
19004	2/25/03	466,572,473	10789	10856	60216	7465	10731	71852

Table F-12. Percent and Actual Differences Between Model and Observed Values in Table B-11.

Subwatershed Number	Date	Total Copper	Total Lead	Total Zinc	Total Copper	Total Lead	Total Zinc
		Percent Difference	Percent Difference	Percent Difference	Actual Difference	Actual Difference	Actual Difference
Units		%	%	%	g	g	g
19004	11/29/01	18%	14%	8%	32.48	27	87
19004	2/17/02	0.5%	68%	-7%	5.0	407	(397)
19004	11/8/02	19%	99%	55%	42.27	132.8	515
19004	2/11/03	14%	32%	-10%	567	1,154	(2,947)
19004	2/25/03	45%	1.2%	-16%	3,324	125	(11,636)

Appendix G

**Metals Concentration
Reduction Percentages**

**Required to Meet the Chollas Creek Metals Total Maximum
Daily Loads**

California Regional Water Quality Control Board, San Diego Region

PUBLIC REVIEW DRAFT

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Metals Concentration Reduction Percentages Required to Meet the Total Maximum Daily Load for Metals in Chollas Creek

The load allocation (LA) and waste load allocations (WLA) of the copper, lead, and zinc Total Maximum Daily Loads (TMDL) for Chollas Creek establish concentrations of copper, lead, and zinc that are protective of aquatic life beneficial uses in Chollas Creek.¹ Because the concentrations protective of aquatic life vary with hardness, the allocations in this TMDL are expressed as formulas that incorporate a hardness term, rather than as a constant concentration. To achieve Water Quality Objectives (WQOs) in the creek, concentrations of copper, lead and zinc must be significantly lower than presently measured. The potential ranges of the reductions should be thoroughly considered, as they will have practical implications on the feasibility and nature of implementation scenarios. Using concentration and hardness data from Chollas Creek, the likely range of metals concentration reduction percentages needed to meet the WQOs for copper, lead and zinc were calculated.

The Numeric Targets for copper, lead and zinc are presented in Table G.1 and are discussed in detail in the Technical Report. Concentrations of metals in Chollas Creek will be compared against the WQOs to assess compliance with this TMDL Project. The TMDLs (equal to the WLA and LA) for copper, lead, and zinc are listed in Table G.2. All discharges to Chollas Creek will be expected to meet this WLA and LA. Average and median concentrations of copper, lead and zinc currently exceed the proposed load and waste load allocations (Table G.3). The data used to calculate the mean and median concentrations can be found in Appendix A. To calculate the percent reductions required to meet the allocations, the following formula was applied:

$$\text{Percent Reduction} = \frac{(\text{Measured Concentration} - \text{WQO})}{\text{Measured Concentration}} \times 100$$

The loading capacity of Chollas Creek is equal to the Numeric Targets that are equal to either the Criteria Maximum Concentration (CMC) or Criteria Continuous Concentration (CCC) calculated from the hardness that is associated with the measured concentration of metal.

Example:

Mean Measured Copper Concentration = 16.6 µg/L

Mean Measured Hardness = 198.2 mg/L

At this hardness;

CCC = 16.1 µg/L

Percent Reduction = $[(16.64 - 16.1) / 16.64] \times 100 = 3.4\%$

CMC = 25.6 µg/L

Percent Reduction = $[(16.64 - 25.6) / 16.64] \times 100 = -54.2\%$

Therefore, if water quality conditions are equal to the mean copper concentration and mean hardness, the ambient copper concentration would need to be decreased by 3.4 percent to

¹ In this concentration based TMDL, the LAs and WLAs are equal to the same concentration, and can vary depending on hardness. The LAs and WLAs are not additive.

achieve the allowable chronic concentration and would not exceed the allowable maximum concentration. Negative percent reductions in Table G.2 indicate that the proposed WQOs are met and a reduction is not needed.

TABLE G.1. Numeric Targets for dissolved copper, lead and zinc for acute and chronic conditions

Metal	Numeric Target for Acute Conditions: Criteria Maximum Concentration	Numeric Target for Chronic Conditions: Criteria Continuous Concentration
Copper	$(0.96) * \{e^{[0.9422 * \ln(\text{hardness}) - 1.700]}\}$	$(0.96) * \{e^{[0.8545 * \ln(\text{hardness}) - 1.702]}\}$
Lead	$(1) * \{1.46203 - [0.145712 * \ln(\text{hardness})]\} * \{e^{[1.273 * \ln(\text{hardness}) - 1.460]}\}$	$\{1.46203 - [0.145712 * \ln(\text{hardness})]\} * \{e^{[1.273 * \ln(\text{hardness}) - 4.705]}\}$
Zinc	$(0.978) * \{e^{[0.8473 * \ln(\text{hardness}) + 0.884]}\}$	$(0.986) * \{e^{[0.8473 * \ln(\text{hardness}) + 0.884]}\}$

TABLE G.2. The Wasteload and Load Allocations for dissolved copper, lead and zinc for acute and chronic conditions

Metal	Allocations for Acute Conditions – One-Hour Average (LA = WLA = 0.9 * Numeric Target)	Allocations for Chronic Conditions – Four-Day Average (LA = WLA = 0.9 * Numeric Target)
Copper	$(0.96) * \{e^{[0.9422 * \ln(\text{hardness}) - 1.700]}\} * 0.9$	$(0.96) * \{e^{[0.8545 * \ln(\text{hardness}) - 1.702]}\} * 0.9$
Lead	$[1.46203 - 0.145712 * \ln(\text{hardness})] * \{e^{[1.273 * \ln(\text{hardness}) - 1.460]}\} * 0.9$	$[1.46203 - 0.145712 * \ln(\text{hardness})] * \{e^{[1.273 * \ln(\text{hardness}) - 4.705]}\} * 0.9$
Zinc	$(0.978) * \{e^{[0.8473 * \ln(\text{hardness}) + 0.884]}\} * 0.9$	$(0.986) * \{e^{[0.8473 * \ln(\text{hardness}) + 0.884]}\} * 0.9$

WLA = Waste Load Allocation

LA = Load Allocation

Table G.3 is for illustrative purposes to frame the potential ranges of reductions in metal concentrations required to meet the proposed WQOs. Many of the scenarios presented do not result in a required reduction.

Table G.3. Average metal concentrations, hardness, associated allocations and percent reductions required

Metal	Total Hardness as CaCO ₃ (mg/L)	CMC Freshwater CF	WQO (ug/L)	LA and WLA	CCC Freshwater CF	WQO (ug/L)	LA and WLA	Measured Concentration	Percent Reduction Required to meet WQO	
		Acute Dissolved			Chronic Dissolved			Dissolved (ug/L)	CMC	CCC
Copper										
Minimum*	42.5	0.96	6.0	5.4	0.96	4.3	3.9	2.4	-150.1%	-79.6%
Median^	90.8	0.96	12.3	11.0	0.96	8.2	7.4	10.0	-22.7%	17.5%
Mean^	198.2	0.96	25.6	23.0	0.96	16.1	14.5	16.6	-53.9%	3.4%
Maximum*	120.0	0.96	16.0	14.4	0.96	10.5	9.4	81.6	80.4%	87.2%
Lead										
Minimum*	35.1	0.944	20.32	18.3	0.944	0.79	0.7	0.50	-3963.5%	-58.4%
Median^	88.9	0.808	56.80	51.1	0.808	2.21	2.0	3.00	-1793.4%	26.2%
Mean^	199.8	0.690	135.99	122.4	0.690	5.30	4.8	14.29	-851.6%	62.9%
Maximum*	71.0	0.841	44.39	40.0	0.841	1.73	1.6	118.00	62.4%	98.5%
Zinc										
Minimum*	484.0	0.978	446	401.2	0.986	449	404.5	3.0	-14759.5%	-14881.0%
Median^	90.8	0.978	108	97.2	0.986	109	98.0	66.5	-62.4%	-63.7%
Mean^	200.2	0.978	211	189.9	0.986	213	191.4	102.2	-106.5%	-108.1%
Maximum*	120.0	0.978	137	123.1	0.986	138	124.1	548.0	75.0%	74.8%

* Uses measured hardness that corresponds to max and min measured metal concentrations

^ Hardness listed is the statistical median or mean, respectively.

CCC = Criteria Continuous Concentration

CMC = Criteria Maximum Concentration

CF = Conversion Factor

LA = Load Allocation

WLA = Waste Load Allocation

WQO = Water Quality Objective

Figures G.1 through G.3 present the available metals data plotted against the associated hardness. The graphs also show CMC and CCC WQOs required at hardness concentrations from 25 to 400 mg/L.² These views of the data better illustrate that the majority of the metals concentration reductions need to occur at the lower hardness concentrations. Both the CMC (acute) and CCC (chronic) WQOs for all metals are exceeded within the lower range of measured hardness.

Thirty-six of eighty-one (39.5 percent) measured copper samples exceed the proposed acute WQO and forty-four (50.5 percent) exceed the proposed chronic WQO. The vast majority of the exceedances occur at or below a hardness of 150 mg/L. The maximum percent reduction required is approximately 90 percent for both the acute and chronic WQOs. The average reduction required is approximately 50 percent to meet the chronic WQO and 40 percent to meet the acute WQO. There is some good news in that almost half of the measured copper samples would not require a reduction under the proposed WQOs.

Eleven of seventy-nine (13.9 percent) measured lead samples exceed the proposed acute WQO and forty-three (54.4 percent) exceed the proposed chronic WQO. The vast majority of the exceedances occur at or below a hardness of 120 mg/L. The maximum percent reduction required is approximately 99 percent for the chronic WQO and 62 percent for the acute WQO. The average reduction required is approximately 66 percent to meet the chronic WQO and 25 percent to meet the acute WQO. Almost half of the measured lead samples

² This is the range of hardness that is appropriate for use in the California Toxics Rule (40 CFR 131.38).

would not require a reduction to meet the proposed chronic WQO and over 85 percent would already meet the proposed acute WQO.

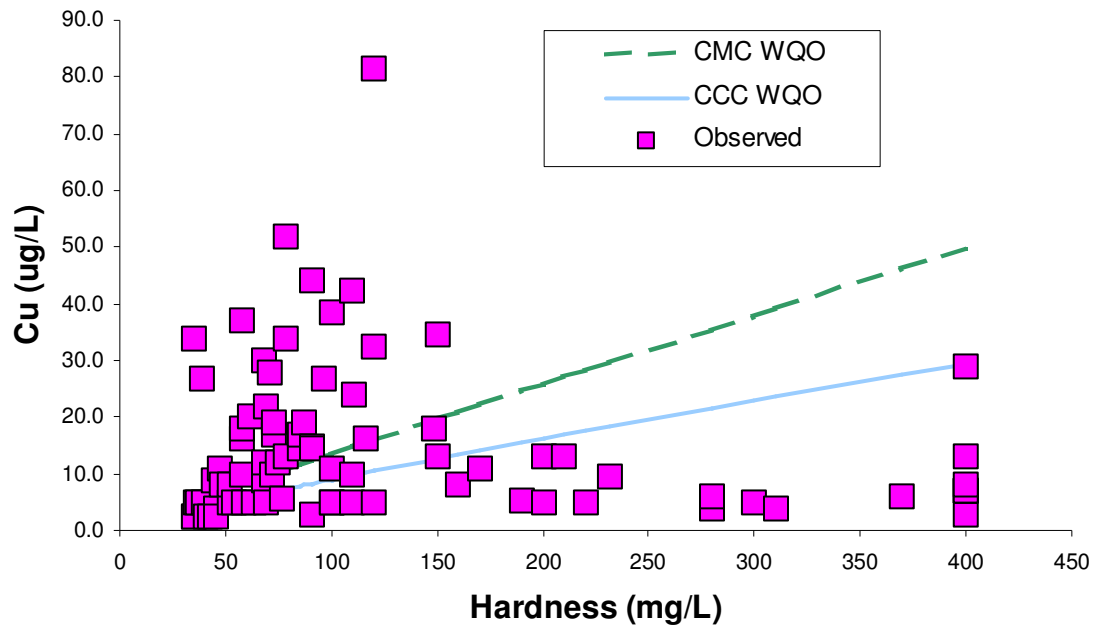


Figure G.1. Copper concentrations in Chollas Creek

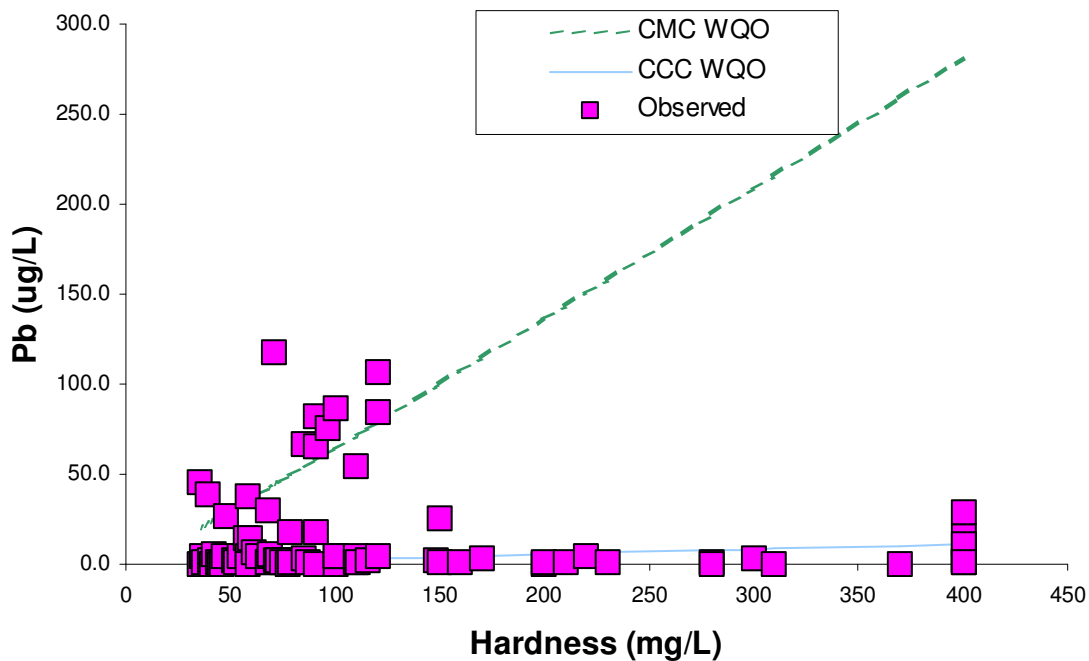


Figure G.2. Lead concentrations in Chollas Creek

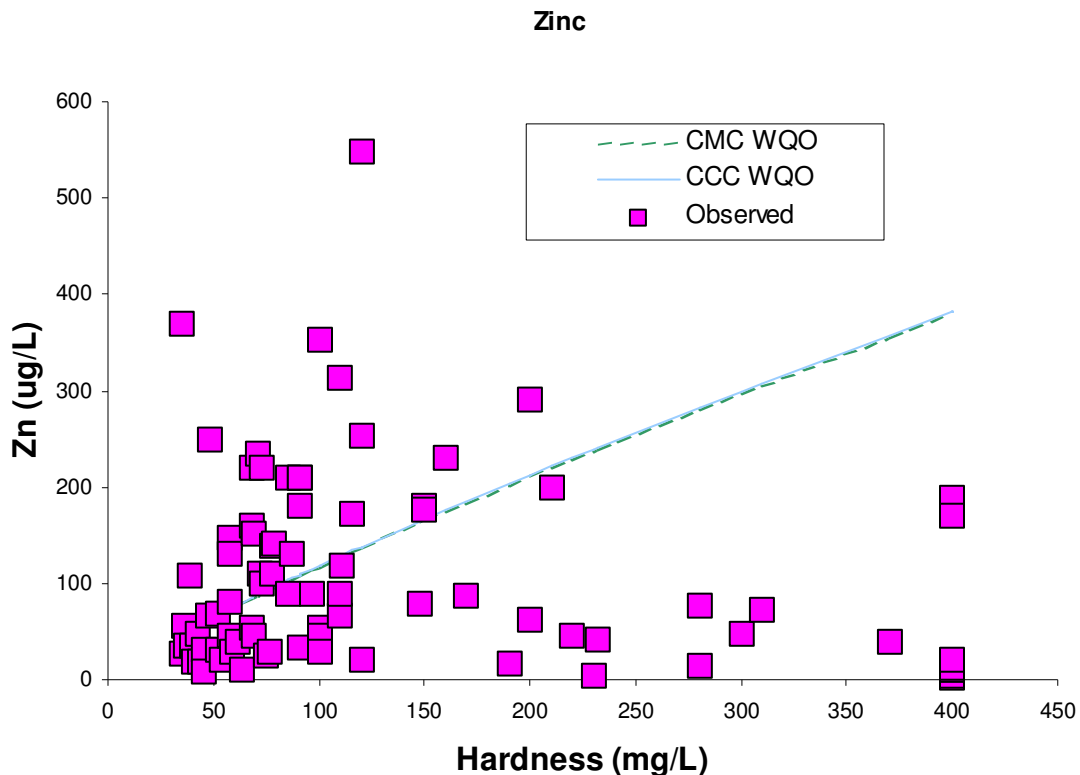


Figure G.3. Zinc concentrations in Chollas Creek

Thirty-three of eighty-two (40 percent) measured zinc samples exceed both the proposed acute and chronic WQOs. All of the exceedances occur at or below a hardness of 210 mg/L. The maximum percent reduction required is approximately 87 percent for both the acute and chronic WQOs, while the average reduction required is approximately 35 percent. For zinc, well over half of the measured samples would not require a reduction under the proposed WQOs.

All three metals require significant reductions from current concentrations to meet the WQOs. Most reductions are required at the lower range of the measured hardness and represent up to a 98 percent reduction. However, the average reduction required is closer to 50 percent and a significant number of previously measured metal concentrations would not require a reduction. This data should be investigated further when implementing best management practices and considering load reduction scenarios.

Appendix H
Site-Specific Objectives

Chollas Creek Metals Total Maximum Daily Loads

California Regional Water Quality Control Board, San Diego Region

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Site-Specific Objectives

Currently, there are no site-specific objectives (SSOs) for the Chollas Creek Metals Total Maximum Daily Load (TMDL) project. The following is the San Diego Regional Water Quality Control Board general comment about developing site-specific objectives with respect to TMDLs.

In the TMDL, the numeric targets are set equal to numeric water quality criteria for dissolved copper, lead, and zinc, as defined in the California Toxics Rule (CTR). The CTR's numeric criteria serve as legally applicable water quality standards in the State of California for inland surface waters, enclosed bays and estuaries for all purposes and programs under the Clean Water Act. Criteria are derived based on a rigorous set of guidelines to provide both short-term and long-term protection to aquatic life. In the absence of site-specific objectives, the CTR's water quality criteria represent the most appropriate water quality objectives and therefore numeric targets for dissolved copper, lead, and zinc at Chollas Creek.

The CTR criteria are based on the toxicity results of a large number of nationally representative species to a single pollutant in clean controlled laboratory waters. The physical and chemical characteristics of ambient water at a particular site may result in an increase or decrease in the bioavailability and/or toxicity of a given pollutant. Examples of potentially confounding water chemistry characteristics may include dissolved organic matter, particulate matter, other contaminants, pH, and hardness. Similarly, the aquatic life community at a particular site may be more or less sensitive to a pollutant than the aquatic organisms used to develop the CTR criteria. Because (1) ambient water chemistry, and/or (2) the biological communities at Chollas Creek may be different than the chemistry and biological communities upon which the CTR criteria were based, the CTR criteria may be over - or under- protective for Chollas Creek.

Differences in bioavailability and toxicity may exist for several reasons, including the presence of dissolved organic matter, particulate matter, other contaminants, pH, and hardness. Additionally, the aquatic organisms that live in the receiving waters may be more or less sensitive than the organisms used in the controlled laboratory waters. Therefore, by definition, site-specific criteria may be more or less stringent than the criteria presented in the CTR.

The Regional Board recognizes that there are situations where site-specific conditions affect the toxicity of a pollutant, which results in a criterion that is over- or under-protective. Water quality criteria are primarily based on studies conducted using laboratory water in which organisms are exposed to one pollutant. Site-specific objectives adjust water quality objectives to account for differences in toxicity among sites based on site-specific information and scientific studies. Site-specific objectives must protect the beneficial uses of a water body, must be developed in accordance with federal and State laws and regulations based on sound scientific rationale and must be adopted by the Regional Board in a Basin Plan amendment..

The Regional Board agrees that it may be appropriate to investigate the relevance of site-specific objectives for copper, lead, and zinc in the Chollas Creek watershed. However, the Regional Board does not plan to initiate or fund studies to develop site-specific objectives. Typically, such studies are initiated by dischargers or other interested parties under the regulatory oversight of the Regional Board. There is no effort currently underway or planned by interested persons to fund the scientific studies needed to develop SSOs for copper, lead, and zinc in Chollas Creek. The development of a copper, lead, and zinc SSOs for Chollas Creek waters, including the scientific studies necessary to support it, would be costly, time consuming and resource intensive. Dischargers or other interested parties would need to fund and initiate the scientific studies to develop SSOs.

The appropriate strategy is for the Regional Board to proceed with adoption of the TMDL at this time, which will mandate copper, lead, and zinc load reductions. If scientific studies demonstrate that the ambient water chemistry and/or biological communities at Chollas Creek are significantly different from the chemistry and biological communities upon which the CTR criterion were based, a site specific objective for copper, lead, and zinc may be appropriate. If and when site-specific copper, lead, and zinc water quality objectives are developed for Chollas Creek, this TMDL will be modified accordingly. The Regional Board will not delay adoption of this TMDL mandating copper, lead, and zinc load reductions on the premise that it is necessary to first develop site-specific copper, lead, and zinc water quality objectives. Studies by interested parties supporting the development and adoption of site-specific objectives may occur concurrently with actions by dischargers to meet compliance with this TMDL. Development of site-specific objectives is discussed in more detail in the State's *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed bays, and Estuaries of California* (State Board, 2000). The State Board's 2000 Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP) provides further guidance on when SSOs may be used.

Appendix I
CEQA Checklist

For the Chollas Creek Metals Total Maximum Daily Loads

California Regional Water Quality Control Board, San Diego Region

PUBLIC REVIEW DRAFT
28 March 2005

Environmental Checklist Form

1. Project title

Resolution R9-2005-0111, Amendment to the Water Quality Control Plan for the San Diego Region (9) to Incorporate Total Maximum Daily Loads for Copper, Lead and Zinc in Chollas Creek

2. Lead agency name and address

California Regional Water Quality Control Board, San Diego Region 9174 Sky Park Court, Suite 100, San Diego, CA 92123-4340

3. Contact person and phone number

Jimmy Smith, Environmental Scientist
(858) 467-2732

4. Project location

Chollas Creek, San Diego County, California

5. Project sponsor's name and address

California Regional Water Quality Control Board, San Diego Region 9174 Sky Park Court, Suite 100, San Diego, CA 92123-4340

6. General plan designation

Not applicable

7. Zoning

Not applicable

8. Description of project

As required by section 303(d) of the federal Clean Water Act, the Regional Board has prepared Total Maximum Daily Loads (TMDLs) for copper, lead and zinc in Chollas Creek. The purpose of the TMDLs is to attain and maintain applicable water quality objectives for copper, lead and zinc and to protect the beneficial uses. The major source of metals to Chollas Creek comes from urban runoff. All sources of metals must comply with the load and wasteload allocations, which are set equal to water quality criteria defined in the California Toxics Rule further reduced by a margin of safety. The Regional Board will amend the Basin Plan to include TMDLs for copper, lead and zinc, an Implementation Plan, and a schedule for achieving compliance with the wasteload and load allocations.

9. Surrounding land uses and setting

Chollas Creek is a highly urbanized watershed. See section 5.2.1 of the Technical Analysis for a detailed discussion of the land uses of the Chollas Creek Watershed.

10. Other public agencies whose approval is required

State Water Resources Control Board

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED:

The environmental resource categories identified below are analyzed herein to determine whether the proposed TMDL Basin Plan amendment would result in adverse impacts to any of these resources. None of the categories below are checked because the proposed TMDL Basin Plan amendment is not expected to result in "potentially significant impacts" to any of these resources.

Aesthetics	Mineral Resources
Public Services	Utilities/Service Systems
Agriculture Resources	Biological Resources
Hazards & Hazardous Materials	Cultural Resources
Hydrology/Water Quality	Noise
Recreation	Mandatory Findings of Significance
Air Quality	Geology/Soils
Land Use Planning	Transportation/Traffic

On the basis of this initial evaluation:

- ☒ I find that the Proposed Project COULD NOT have a significant effect on the environment,
- ☐ I find that although the Proposed Project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the Project have been made by or agreed to by the Project proponent.
- ☐ I find that the Proposed Project MAY have a significant effect on the environment.
- ☐ I find that the Proposed Project MAY have a "potentially significant impact" or "potentially significant unless mitigated" impact on the environment, but at least one effect: (1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and (2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An ENVIRONMENTAL IMPACT REPORT is required, but it must analyze only the effects that remain to be addressed.
- ☐ I find that although the Proposed Project could have a significant effect on the environment because all potentially significant effects (a) have been analyzed adequately in an earlier EIR or NEGATIVE DECLARATION pursuant to applicable standards, and (b) have been avoided or mitigated pursuant to that earlier EIR or NEGATIVE DECLARATION, including revisions or mitigation measures that are imposed upon the Proposed Project, nothing further is required.

John H. Robertus
Executive Officer

Date

EVALUATION OF ENVIRONMENTAL IMPACTS

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
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I. AESTHETICS Would the Project:

a) Have a substantial adverse effect on a scenic vista?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Substantially degrade the existing visual character or quality of the site and its surroundings?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

II. AGRICULTURE RESOURCES: In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the Project:

a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

III. AIR QUALITY – Where available, the significance criteria established by the applicable air quality management or air pollution control the District may be relied upon to make the following determinations. Would the Project:

a) Conflict with or obstruct implementation of the applicable air quality plan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Violate any air quality standard or contribute	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
substantially to an existing or projected air quality violation?				
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the Project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) Expose sensitive receptors to substantial pollutant concentrations?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e) Create objectionable odors affecting a substantial number of people?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

IV. BIOLOGICAL RESOURCES – Would the Project:

a) Have a substantial adverse effect, either directly, or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulators, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) Have a substantial adverse effect on federally protected wetlands as defined by section 404 of the Clean Water Act (including, but not limited to, marsh vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f) Conflict with the provisions of an adopted	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?				

V. CULTURAL RESOURCES – Would the Project:

a) Cause a substantial adverse change in the significance of a historical resource as defined in section 15064.5?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to section 15064.5?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Directly or indirectly destroy a unique paleontological resource of site or unique geological feature?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) Disturb any human remains, including those interred outside of formal cemeteries?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

VI. GEOLOGY AND SOILS – Would the Project:

a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ii) Strong seismic ground shaking?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
iii) Seismic-related ground failure,, including liquefaction?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
iv) Landslides?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Result in substantial soil erosion or the loss of topsoil?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform building Code (1994), creating substantial risks to life or property?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

VII. HAZARDS AND HAZARDOUS MATERIALS – Would the Project:

a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e) For a Project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the Project result in a safety hazard for people residing or working in the Project area?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f) For a Project within the vicinity of a private airstrip, would the Project result in a safety hazard for people residing or working in the Project area?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

VIII. HYDROLOGY AND WATER QUALITY – Would the Project:

a) Violate any water quality standards or waste	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
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IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
discharge requirements?				
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of preexisting nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which results in flooding on- or off-site?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e) Create or contribute runoff water which exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f) Otherwise substantially degrade water quality?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
j) Inundation by seiche, tsunami, or mudflow?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
IX. LAND USE AND PLANNING – Would the Project:				
a) Physically divide an established community?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Conflict with any applicable land use plan,				

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
policy, or regulation of an agency with jurisdiction over the Project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

X. MINERAL RESOURCES – Would the Project:

a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

XI. NOISE – Would the Project result in:

a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) A substantial permanent increase in ambient noise levels in the Project vicinity above levels existing without the Project?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) A substantial temporary or periodic increase in ambient noise levels in the Project vicinity above levels existing without the Project?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e) For a Project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the Project expose people residing or working in the Project area to excessive noise levels?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f) For a Project within the vicinity of a private airstrip, would the Project expose people residing or working in the Project area to excessive noise levels?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

XII. POPULATION AND HOUSING – Would the Project?

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

XIII. PUBLIC SERVICES

a) Would the Project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:

Fire protection?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Police protection?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Schools?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Parks?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Other public facilities?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

XIV. RECREATION

a) Would the Project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
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b) Does the Project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
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XV. TRANSPORTATION/TRAFFIC – Would the Project:

a) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
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IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
volume to capacity ratio to roads, or congestion at intersections?				
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion/management agency for designated roads or highways?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e) Result in inadequate emergency access?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f) Result in inadequate parking capacity?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
g) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

XVI. UTILITIES AND SERVICE SYSTEMS – Would the Project?

a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) Have sufficient water supplies available to serve the Project from existing entitlements and resources, or are new or expanded entitlements needed?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e) Result in a determination by the wastewater treatment provider which serves or may serve the Project that it has adequate capacity to serve the	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

IMPACT	POTENTIALLY SIGNIFICANT IMPACT	POTENTIALLY SIGNIFICANT UNLESS MITIGATION INCORPORATION	LESS THAN SIGNIFICANT IMPACT	NO IMPACT
Project's projected demand in addition to the provider's existing commitments?				
f) Be served by a landfill with sufficient permitted capacity to accommodate the Project's solid waste disposal needs?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
g) Comply with federal, state, and local statutes and regulations related to solid waste?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

XVII. MANDATORY FINDINGS OF SIGNIFICANCE

a) Does the Project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number of restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Does the Project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probably future projects)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Does the Project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Discussion of Possible Environmental Impacts and Appropriate Mitigation Measures

Part IV, b) - Question: Would the project have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?

Answered " Potentially Significant Unless Mitigation Incorporation "

Depending on the BMPs chosen for implementation to comply with the TMDL, the project may result in potential adverse environmental impacts unless mitigation is incorporated into the BMP. Adverse environmental impacts are more often associated with treatment control BMPs rather than source control BMPs. Examples of potential impacts and mitigation associated with treatment control BMPs that might be implemented are discussed below. Keep in mind that the Basin Plan amendment does not specify the BMPs to be implemented by the dischargers, but rather, allows the dischargers to select BMPs to meet load and waste load reductions of copper, lead and zinc in Chollas Creek.

In order to remove metals during dry weather, diversion systems may be put into place in Chollas Creek. While the use of diversion systems during dry weather may result in decreased metal concentrations in the creek, the removal of water from the creek could alter the hydrology of the stream and result in adverse impacts to aquatic life dependent on the stream. Mitigation to lessen any such impacts may involve diverting only a portion of the water from the creek sufficient to remove metals but not to significantly alter the creek's hydrology. An additional mitigation measure could involve returning treated water to the stream. In this situation, consideration should be given to release the treated water back into the creek in the same location, and at the temperature and flow velocity to maintain the creek's hydrograph. Another potential adverse impact resulting from the use of diversion systems involves the potential for entrainment of fauna and flora from the creek. As a mitigation measure to avoid entraining flora and fauna, diversion systems may be set up that divert flow "in-pipe", i.e. in the storm drain, rather than in the creek. Furthermore, screens may be put into place to help prevent the uptake of aquatic organisms. Diversion systems should be properly maintained to ensure that they function appropriately and do not result in adverse environmental impacts.

Potential adverse impacts may also result from the use of treatment control BMPs that increase the likelihood of vectors and pests. For example, constructed basins and vegetated swales may develop locations of pooled standing water that would increase the likelihood of mosquito breeding. Mitigation may involve the prevention of standing water through the construction and maintenance of appropriate drainage slopes and through the use of aeration pumps.¹ Mitigation for vectors and pests should involve the

¹ <http://www.cabmphandbooks.com/Municipal.asp>

use of appropriate vector and pest control strategies and maintenance such as frequent inspections to prevent adverse environmental impacts.

Certain types of treatment control BMPs such as infiltration trenches and infiltration basins may result in the accumulation of metals to potentially hazardous levels. The accumulation of metals in turn could lead to contamination of groundwater. Mitigation may involve regular inspections, monitoring, and maintenance including disposal of waste at appropriate landfills when necessary.

Another potential adverse environmental impact could result from the introduction and/or establishment of invasive species in wet ponds and bioretention BMPs. Vegetation should be chosen to help reduce or eliminate this possibility, and the BMPs should be maintained and inspected routinely to identify the establishment of any potentially invasive species.

In conclusion, implementation measures should be chosen to reduce metals loading to Chollas Creek. Efforts should first be aimed at source control and then at treatment control since treatment control BMPs have greater potential for adverse environmental impacts. Appropriate mitigation including frequent inspections and maintenance should be incorporated to reduce or eliminate any adverse environmental impacts.

Appendix J

TENTATIVE RESOLUTION NO. R9-2005-0111

AND

ATTACHMENT A

**AMENDMENT TO THE WATER QUALITY CONTROL PLAN
FOR THE SAN DIEGO REGION TO INCORPORATE
TOTAL MAXIMUM DAILY LOADS FOR DISSOLVED
COPPER, LEAD AND ZINC IN CHOLLAS CREEK,
TRIBUTARY TO SAN DIEGO BAY**

**AND TO REVISE THE WATER QUALITY OBJECTIVES FOR
TOXIC POLLUTANTS**

For the Chollas Creek Metals Total Maximum Daily Loads

California Regional Water Quality Control Board, San Diego Region

**PUBLIC REVIEW DRAFT
28 MARCH 2005**

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD SAN DIEGO REGION

TENTATIVE RESOLUTION NO. R9-2005-0111

A RESOLUTION ADOPTING AN AMENDMENT TO THE WATER QUALITY CONTROL PLAN FOR THE SAN DIEGO REGION TO INCORPORATE TOTAL MAXIMUM DAILY LOADS FOR DISSOLVED COPPER, LEAD AND ZINC IN CHOLLAS CREEK, TRIBUTARY TO SAN DIEGO BAY

WHEREAS, The California Regional Water Quality Control Board, San Diego Region (hereinafter, Regional Board), finds that:

1. **BASIN PLAN AMENDMENT:** The proposed amendment of the Water Quality Control Plan for the San Diego Basin – Region 9 (Basin Plan) described in the recitals below was developed in accordance with Water Code section 13240 et seq.
2. **NECESSITY STANDARD** [Government Code section 11353(b)]: This regulatory action meets the “Necessity” standard of the Administrative Procedures Act, Government Code, section 11353, subdivision (b). Amendment of the Basin Plan to establish and implement a Total Maximum Daily Load (TMDL) for Chollas Creek is necessary because the existing water quality does not meet applicable numeric water quality objectives for copper, lead or zinc or narrative water quality objectives for toxicity. The federal Clean Water Act (CWA) section 303(d) requires the Regional Board to establish and mandate implementation of TMDLs under the water quality conditions that exist in Chollas Creek. These TMDLs for copper, lead and zinc are necessary to ensure attainment of applicable water quality objectives and restoration of beneficial uses designated for Chollas Creek.
3. **CLEAN WATER ACT SECTION 303(d):** The lowest 1.2 miles of Chollas Creek were placed on the List of Water Quality Limited Segments, as required by Clean Water Act section 303(d), in 1996 due to elevated levels of dissolved copper, lead and zinc (metals) in the water column.
4. **BENEFICIAL USE IMPAIRMENTS:** Chollas Creek has two beneficial uses impaired by elevated concentrations of dissolved metals in the water column. These sensitive beneficial uses are designated for protection of aquatic life and aquatic dependent wildlife as described in the Basin Plan definition of the warm freshwater habitat (WARM) and wildlife habitat (WILD) beneficial uses. The WARM and WILD beneficial uses of Chollas Creek are threatened or impaired due to elevated levels of dissolved copper, lead and zinc.
5. **WATER QUALITY OBJECTIVES:** The water quality objectives for dissolved copper, lead and zinc in Chollas Creek specify that concentrations should not exceed the water quality criteria set forth in the California Toxics Rule (CTR) for acute and chronic conditions. The CTR water quality criteria for dissolved copper, lead and zinc promulgated by the U.S. Environmental Protection Agency (USEPA), are the legally applicable water

quality standards in the State of California for inland surface waters, enclosed bays, and estuaries for all purposes and programs under the CWA. The water quality objectives are presented below.

Water Quality Objectives for dissolved metals in Chollas Creek.

Metal	Numeric Target for Acute Conditions: Criteria Maximum Concentration	Numeric Target for Chronic Conditions: Criteria Continuous Concentration
Copper	$(1) * (0.96) * \{e^{[0.9422 * \ln(\text{hardness}) - 1.700]}\}$	$(1) * (0.96) * \{e^{[0.8545 * \ln(\text{hardness}) - 1.702]}\}$
Lead	$(1) * \{1.46203 - [0.145712 * \ln(\text{hardness})]\} * \{e^{[1.273 * \ln(\text{hardness}) - 1.460]}\}$	$(1) * \{1.46203 - [0.145712 * \ln(\text{hardness})]\} * \{e^{[1.273 * \ln(\text{hardness}) - 4.705]}\}$
Zinc	$(1) * (0.978) * \{e^{[0.8473 * \ln(\text{hardness}) + 0.884]}\}$	$(1) * (0.986) * \{e^{[0.8473 * \ln(\text{hardness}) + 0.884]}\}$

Hardness is expressed as milligrams per liter.

Calculated concentrations should have two significant figures (40 CFR 131.38(b)(2)).

The natural log and exponential functions are represented as “ln” and “e”, respectively.

In addition, the Basin Plan establishes the following narrative water quality objective for “toxicity” to ensure the protection of the WARM and WILD beneficial uses.

Toxicity Objective: *All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Board.*

The survival of aquatic life in surface waters subjected to a waste discharge or other controllable water factors, shall not be less than that for the same water body in areas unaffected by the waste discharge or, when necessary, for other control water that is consistent with requirements specified in USEPA, State Water Resources Control Board (State Board) or other protocol authorized by the Regional Board. As a minimum, compliance with this objective as stated in the previous sentence shall be evaluated with a 96-hour acute bioassay.

In addition, effluent limits based upon acute bioassays of effluents will be prescribed where appropriate, additional numerical receiving water objectives for specific toxicants will be established as sufficient data become available, and source control of toxic substances will be encouraged.

- NUMERIC TARGETS:** TMDL Numeric Targets interpret and implement water quality standards (i.e., numeric and narrative water quality objectives and beneficial uses) and are established at levels necessary to achieve water quality standards. The Regional Board has

set the copper, lead and zinc TMDL Numeric Targets for both the numeric and narrative water quality objectives equal to the numeric water quality objectives cited in Finding 5. Attainment of the TMDL numeric targets will result in attainment of water quality standards in Chollas Creek.

7. **SOURCES OF DISSOLVED METALS:** An analysis of source contributions reveal many land uses and activities associated with urbanization to be potential sources of copper, lead and zinc to Chollas Creek. Modeling efforts point toward freeways and commercial/ industrial land uses as the major contributors. Review of studies from other similar urban areas confirms that automobiles can be a significant source of all three metals. Other suspected individual sources of copper, lead and zinc are water supply systems, pesticides, industrial metal recyclers and other industrial activities.
8. **WATER QUALITY OBJECTIVE VIOLATIONS:** Concentrations of dissolved copper, lead and zinc have frequently exceeded applicable water quality criteria contained in the CTR and are thus in violation of the Basin Plan narrative water quality objective for Toxicity. Furthermore, in a Toxicity Identification Evaluation performed in 1999, storm water concentrations of zinc and to a lesser extent copper, were identified as causing reduced fertility in the purple sea urchin.
9. **ADVERSE EFFECTS OF COPPER, LEAD AND ZINC:** Concentrations of copper, lead and zinc, in excess of CTR criteria, are believed to cause adverse effects in biological species. Copper, lead, and zinc may bioaccumulate within lower organisms, however they do not biomagnify up the food chain. Of these three metals, copper is considered the most potent toxin at environmentally relevant aqueous concentrations.
10. **TOTAL MAXIMUM DAILY LOADS AND ALLOCATIONS:** The assimilative or loading capacity of Chollas Creek for dissolved copper, lead and zinc is defined as the maximum amount that Chollas Creek can receive and still attain water quality objectives and protection of designated beneficial uses. The TMDL is comprised of the sum of all individual Wasteload Allocations (WLAs) for point source discharges, the sum of all Load Allocations (LAs) for nonpoint source discharges, and natural background. The TMDL includes a margin of safety (MOS) that takes into account any uncertainties in the TMDL calculation. The TMDL calculations also account for seasonal variations and critical conditions [40 Code of Federal Regulations (CFR), section 130.2(i)].

The TMDLs for dissolved copper, lead and zinc are equal to 90 percent of the CTR Criteria Continuous Concentration (CCC) and Criteria Maximum Concentration (CMC) equations. The load and wasteload allocations are equal to the TMDL. The allowable TMDL concentrations will be determined with hardness values measured at the time of compliance monitoring; thus resulting in a direct measure of any seasonal variations and/or critical condition effects on hardness.

11. **WASTELOAD REDUCTIONS:** Concentrations of dissolved copper, lead and zinc require significant reductions from current concentrations to meet the allocations. Most reductions are required at the lower range of the measured hardness and represent up to a 99 percent

reduction. However, the average reduction required is closer to 50 percent and a significant number of previously measured metal concentrations would not require a reduction to meet the proposed Numeric Targets.

12. **IMPLEMENTATION PLAN:** The necessary actions to implement the TMDL are described in the technical report entitled *Total Maximum Daily Loads for Dissolved Copper, Lead and Zinc in Chollas Creek*, dated [insert date]. These actions will be accomplished by the Regional Board and State Water Resources Control Board (State Board) by amending the WDRs that regulate MS4 discharges, industrial facility stormwater discharges, and groundwater extraction discharges in the Chollas Creek watershed.
13. **COMPLIANCE MONITORING:** Water quality monitoring will be required to assess progress in achieving WLAs and compliance in Chollas Creek with the water quality objectives for dissolved copper, lead, and zinc.
14. **COMPLIANCE SCHEDULE:** Copper, lead and zinc wasteload reductions are required over a 7-year staged compliance schedule period. No reductions are required for the first three years. The subsequent four-year period requires incremental reductions capable of achieving the percentage of allowable exceedances of the WLA in discharges until no exceedances are allowed at the end of the seventh year following approval of the TMDLs by the Office of Administrative Law (OAL).
15. **SCIENTIFIC PEER REVIEW:** The scientific basis of this TMDL has undergone external peer review pursuant to Health and Safety Code section 57-004. The Regional Board has considered and responded to all comments submitted by the peer review panel.
17. **STAKEHOLDER PARTICIPATION:** Interested persons and the public have had reasonable opportunity to participate in review of the amendment to the Basin Plan. Efforts to solicit public review and comment included five public workshops held between April 1999 and April 2005; a public review and comment period of 45 days preceding the Regional Board public hearing; and written responses from the Regional Board to oral and written comments received from the public.
18. **CEQA REQUIREMENTS:** The Regional Board's Basin Plan amendment process is certified as "functionally equivalent" to the CEQA process and is therefore exempt from CEQA's requirements to prepare an EIR, Negative Declaration, or Initial Study. The required environmental documentation (Basin Plan amendment, technical report, and environmental checklist) has been prepared. A public CEQA scoping meeting was held in March 2003.

The analysis contained in the TMDL Technical Report, the CEQA checklist, and the responses to comments comply with the requirements of the State Board's certified regulatory CEQA process, as set forth in the California Code of Regulations, Title 23, section 3375 et seq. Furthermore, the analysis fulfills the Regional Board's obligations attendant with the adoption of regulations "requiring the installation of pollution control equipment, or

a performance standard treatment or requirement,” as set forth in section 21159 of the Public Resources Code.

19. **ECONOMIC ANALYSIS:** The Regional Board has considered the costs of the reasonably foreseeable methods of compliance with the wasteload reductions specified in this TMDL.
20. **DE MINIMUS ENVIRONMENTAL EFFECTS:** This Basin Plan amendment will result in no potential for adverse effect, either individually or cumulatively, on wildlife.
21. **PUBLIC NOTICE:** The Regional Board has notified all known interested persons and the public of its intent to consider adoption of this Basin Plan amendment in accordance with Water Code section 13244.
22. **PUBLIC HEARING:** The Regional Board has, at a public meeting on [insert date], held a public hearing and heard and considered all comments pertaining to this Basin Plan amendment.
23. **REVISION TO WATER QUALITY OBJECTIVES FOR TOXIC POLLUTANTS:**
Chapter 3 of the Basin Plan needs to be revised to reflect existing federal law. The water quality objectives for toxic pollutants need to incorporate the California Toxics Rule [40 CFR 131.38] numeric criteria as water quality objectives for toxic pollutants in inland surface waters, enclosed bays, and estuaries in the San Diego Region.

In May 2000, the USEPA promulgated numeric water quality criteria for priority toxic pollutants and other water quality standard provisions to be applied to waters in California (California Toxics Rule (CTR); 40 CFR 131.38). The CTR serves as a place holder until the State re-adopts its own numeric criteria for toxics. The CTR established numeric water quality criteria legally applicable in the State of California as WQOs for inland surface waters and enclosed bays and estuaries.

The CTR does not contain acute and chronic numeric criteria for mercury to protect freshwater and saltwater aquatic life; acute numeric criteria for selenium to protect freshwater aquatic life, nor numeric criteria for chloroform. California remains in the National Toxics Rule (40 CFR 131.36), promulgated in 1992 for certain waters and pollutants.

NOW, THEREFORE, BE IT RESOLVED that

1. **AMENDMENT ADOPTION:** The Regional Board hereby adopts this amendment to the Basin Plan to incorporate the TMDLs for dissolved copper, lead and zinc in Chollas Creek as set forth in Attachment A hereto.
2. **TECHNICAL REPORT APPROVAL:** The Regional Board hereby approves the Technical Report entitled *Total Maximum Daily Loads for Dissolved Copper, Lead, and Zinc in Chollas Creek, Tributary to San Diego Bay*, dated [insert date].

3. **CERTIFICATE OF FEE EXEMPTION:** The Executive Officer is authorized to sign a Certificate of Fee Exemption.
4. **AGENCY APPROVALS:** The Executive Officer is directed to submit this Basin Plan amendment to the State Board in accordance with Water Code section 13245. The Regional Board requests that the State Board approve the Basin Plan amendment and forward it to the OAL and the USEPA for approval.
5. **NON-SUBSTANTIVE CORRECTIONS:** If, during the approval process for this amendment, the State Board or OAL determines that minor, non-substantive corrections to the language of the amendment are needed for clarity or consistency, the Executive Officer may make such changes, and shall inform the Regional Board of any such changes.

I, John H. Robertus, Executive Officer, do hereby certify the foregoing is a full, true and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, San Diego Region, on [insert date].

JOHN H. ROBERTUS
EXECUTIVE OFFICER

ATTACHMENT A TO RESOLUTION NO. R9-2005-0111

AMENDMENT TO THE WATER QUALITY CONTROL PLAN FOR THE SAN DIEGO REGION TO INCORPORATE TOTAL MAXIMUM DAILY LOADS FOR DISSOLVED COPPER, LEAD AND ZINC IN CHOLLAS CREEK, TRIBUTARY TO SAN DIEGO BAY,

AND TO REVISE THE WATER QUALITY OBJECTIVES FOR TOXIC POLLUTANTS

This Basin Plan amendment establishes a Total Maximum Daily Load (TMDL) and associated load and wasteload allocations for copper, lead and zinc in Chollas Creek. This amendment includes a program to implement the TMDL and monitor its effectiveness. Chapters 2, 3, and 4 of the Basin Plan are amended as follows:

Chapter 2, Beneficial Uses

Table 2-2. Beneficial Uses of Inland Surface Waters

Add the following footnote 3 to Chollas Creek

³Chollas Creek is designated as an impaired water body for copper, lead and zinc pursuant to Clean Water Act section 303(d). A Total Maximum Daily Load (TMDL) has been adopted to address this impairment. See Chapter 3, Water Quality Objectives for Toxicity and Toxic Pollutants and Chapter 4, Total Maximum Daily Loads.

Chapter 3, Water Quality Objectives

Inland Surface Waters, Enclosed Bays and Estuaries, Coastal Lagoons, and Ground Waters

Water Quality Objectives for Toxic Pollutants:

Revise as follows:

Federal Register, Volume 57, Number 246 amended Title 40, Code of Federal Regulations, Part 131.36 (40 CFR 131.36) and established numeric criteria for a limited number of priority toxic pollutant for inland surface waters and estuaries in California. USEPA promulgated these criteria on December 22, 1992, to bring California into full compliance with section 303(c)(2)(B) of the Clean Water Act. California is not currently in full compliance with this section of the Clean Water Act due to the invalidation of the Water Quality Control Plan for Inland Surface Waters of California and the Water Quality Control Plan for Bays and Estuaries of California. In May 2000, the USEPA promulgated numeric water quality criteria for priority toxic pollutants and other water quality standard provisions to be applied to waters in California (California Toxics Rule (CTR); 40 CFR 131.38). The CTR serves as a place holder until the State re-adopts its own numeric criteria for toxics. The CTR does not contain acute and chronic numeric criteria for mercury to protect freshwater and saltwater aquatic life; acute numeric criteria for selenium to protect freshwater

aquatic life, nor numeric criteria for chloroform. However, the criteria established in 57 FR 60848 (December 22, 1992) (specifically pages 60920-60921) are still applicable to surface waters in the Region.

Water Quality Objectives for Toxic Pollutants:

Inland surface waters, enclosed bays, and estuaries shall not contain toxic pollutants in excess of the numerical objectives applicable to California specified in 40 CFR 131.38 (section 131.38 added at 65 FR 31682-331719, May 18, 2000). 40-CFR131.36 (§ section131.36 revised at 57 FR60848, December 22, 1992).

Chollas Creek is designated as a water quality limited segment for dissolved copper, lead and zinc pursuant to Clean Water Act section 303(d). Total Maximum Daily Loads have been adopted to address these impairments. See Chapters 2, Table 2-2, Beneficial Uses of Inland Surface Waters, Footnote 3 and Chapter 4, Total Maximum Daily Loads.

Chapter 4, Implementation

After the subsection on the TMDL for Dissolved Copper, Shelter Island Yacht Basin, San Diego Bay add the following subsection:

Total Maximum Daily Loads for Copper, Lead and Zinc in Chollas Creek

On [insert date], the Regional Board adopted Resolution No. R9-2005-0111, *A Resolution Adopting an Amendment to the Water Quality Control Plan for the San Diego Region to Incorporate Total Maximum Daily Loads for Dissolved Copper, Lead and Zinc in Chollas Creek, Tributary to San Diego Bay*. The TMDL Basin Plan Amendment was subsequently approved by the State Water Resources Control Board on [Insert Date], the Office of Administrative Law on [Insert Date], and the United States Environmental Protection Agency on [Insert Date].

Problem Statement

Dissolved copper, lead and zinc concentrations in Chollas Creek violate numeric water quality objectives for copper, lead, zinc promulgated in the California Toxics Rule, and the narrative objective for toxicity. Concentrations of these metals in Chollas Creek threaten and impair the designated beneficial uses of warm freshwater habitat (WARM), and wildlife habitat (WILD).

Numeric Targets

The TMDL Numeric Targets for copper, lead and zinc are set equal to the numeric water quality objectives as defined in the California Toxics Rule (CTR) and shown below. Because the concentration of a dissolved metal causing a toxic effect varies significantly with hardness, the water quality objectives are expressed in the CTR as hardness based equations. The numeric targets are equal to the loading capacity of these metals in Chollas Creek.

Table 4. *[insert number]* Water Quality Objectives/Numeric Targets for dissolved metals in Chollas Creek.

Metal	Numeric Target for Acute Conditions: Criteria Maximum Concentration	Numeric Target for Chronic Conditions: Criteria Continuous Concentration
Copper	$(1) * (0.96) * \{e^{[0.9422 * \ln(\text{hardness}) - 1.700]}\}$	$(1) * (0.96) * \{e^{[0.8545 * \ln(\text{hardness}) - 1.702]}\}$
Lead	$(1) * \{1.46203 - [0.145712 * \ln(\text{hardness})]\} * \{e^{[1.273 * \ln(\text{hardness}) - 1.460]}\}$	$(1) * \{1.46203 - [0.145712 * \ln(\text{hardness})]\} * \{e^{[1.273 * \ln(\text{hardness}) - 4.705]}\}$
Zinc	$(1) * (0.978) * \{e^{[0.8473 * \ln(\text{hardness}) + 0.884]}\}$	$(1) * (0.986) * \{e^{[0.8473 * \ln(\text{hardness}) + 0.884]}\}$

Hardness is expressed as milligrams per liter.

Calculated concentrations should have two significant figures (40 CFR 131.38(b)(2)).

The natural log and exponential functions are represented as “ln” and “e”, respectively.

Source Analysis

The vast majority of metals loading to Chollas Creek are believed to come through the storm water conveyance system. An analysis of source contributions reveals many land uses and activities associated with urbanization to be potential sources of copper, lead and zinc to Chollas Creek. Modeling efforts point toward freeways and commercial/industrial land uses as the major contributors

Total Maximum Daily Loads

The TMDLs for dissolved copper, lead and zinc in Chollas Creek is concentration-based and set equal to 90 percent of the Numeric Targets/Loading Capacity.

Margin of Safety

The TMDL includes an explicit margin of safety (MOS). Ten percent of the loading capacity was reserved as an explicit MOS.

Allocations and Reductions

The source analysis showed that nonpoint sources and background concentrations of metals are insignificant, and thus, were set equal to zero in the TMDL calculations. The wasteload allocations are set equal to 90 percent of the numeric targets/loading capacity. Concentrations of dissolved copper, lead and zinc require significant reductions from current concentrations to meet the loading capacity. Most reductions are required at the lower range of the measured hardness and represent up to a 99 percent reduction. However, the average reduction required is closer to 50 percent and a significant number of previously measured metal concentrations meet the proposed loading capacity.

TMDL Implementation Plan

Persons whose point source discharges contribute to the exceedance of WQOs for copper, lead and zinc in Chollas Creek will be required to meet the WLA hardness dependant concentrations

in their urban runoff discharges before it is discharged to Chollas Creek. Actions to meet the WLAs in discharges to Chollas Creek will be required in WDRs that regulate MS4 discharges, industrial facility stormwater discharges, and groundwater extraction discharges in the Chollas Creek watershed. The following orders will be amended by the Regional Board to include actions to meet the WLAs:

Order No. 2001-01, NPDES No. CAS0108758, Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm Sewer Systems Draining the Watersheds of the County of San Diego, the Incorporated Cities of San Diego County, and the San Diego Unified Port District, or subsequent superceding NPDES renewal orders.

Order No. 2000-90, NPDES No. CAG19001, General Waste Discharge Requirements for Temporary Groundwater Extraction and Similar Waste Discharges to San Diego Bay and Storm Drains or other Conveyance Systems Tributary Thereto, or subsequent superceding NPDES renewal orders.

The Regional Board shall request the State Water Resources Control Board to amend the following statewide orders:

Order No. 99-06-DWQ, NPDES No. CAS000003, National Pollutant Discharge Elimination System (NPDES) Permit, Statewide Storm Water Permit, and Waste Discharge Requirements (WDRs) for the State of California, Department of Transportation (Caltrans), or subsequent superceding NPDES renewal orders.

Order No. 97-03-DWQ, NPDES No. CAS 000001, Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities, or subsequent superceding NPDES renewal orders.

Order No. 2003-0005-DWQ, NPDES No. CAS000004, Waste Discharge Requirements for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems, or subsequent superceding NPDES renewal orders.

With respect to specific orders and dischargers, the Regional Board shall:

1. **CalTrans – Amend Order No. 99-06-DWQ, Statewide WDRs for CalTrans MS4 Discharges**

The Regional Board shall request the SWRCB amend Order No. 99-06, the statewide CalTrans NPDES MS4 order to include the following:

- a. The WLAs and schedule of compliance applicable to MS4 discharges into Chollas Creek described in Table 4.**[insert number]**.
- b. A requirement to implement an iterative BMP approach of expanded or better-tailored BMPs to attain the WLAs in Table 4.**[insert number]** in accordance with the compliance schedule in Table 4.**[insert number]**.

- c. A requirement to submit annual progress reports to the Regional Board on the progress in attaining the WLAs in urban runoff discharges and WQOs in Chollas Creek. The reports shall be due on April 1 of each year and shall be incorporated within the report required by section 2, Program Management of Order No. 99-06. Reporting shall continue on an annual basis until the metals WQOs are attained and maintained in Chollas Creek.

The reports should describe the BMPs being implemented by CalTrans in the Chollas Creek watershed and additional BMPs that will be implemented. The reports should describe the steps CalTrans will take to develop a long-term strategy for assessing the effectiveness of its BMPs. The long-term assessment strategy should identify specific direct and indirect measurements that it will use to track the long-term progress towards achieving the copper, lead and zinc load reductions required under this TMDL. Methods used for assessing effectiveness should include the following or their equivalent: surveys, pollutant loading estimations, and receiving water quality monitoring. The long-term strategy should also discuss the role of monitoring data in substantiating or refining the assessment.

2. **Municipal Dischargers¹ - Amend Regional Board Order No. 2001-01, WDRs for San Diego County MS4 Discharges**

The Regional Board shall amend Order No. 2001-01 to include:

- a. The WLAs and schedule of compliance applicable to MS4 discharges into Chollas Creek described in Table 4. *[insert number]*.
- b. A requirement to implement an iterative BMP approach of expanded or better-tailored BMPs to attain the WLAs in Table 11.1 in accordance with the compliance schedule in Table 4. *[insert number]*.
- c. A requirement that the Municipal Dischargers submit annual progress reports to the Regional Board on the progress in attaining the WLAs in effluent discharges and WQOs in Chollas Creek. Annual reports shall cover the period of July 1 through June 30. The reports shall be submitted to the Regional Board by January 31 of the following year and shall be incorporated within the annual receiving water monitoring reports required in Table 6, Item 28, page 51 of Order No. 2001-01. Reporting shall continue on an annual basis until the metal water quality objectives are attained and maintained in Chollas Creek.

The reports should describe the BMPs being implemented by the Municipal Dischargers in the Chollas Creek watershed and additional BMPs that will be implemented. The reports should describe the steps the Municipal Dischargers will take to develop a long-term strategy for assessing the effectiveness of their BMPs. The long-term assessment strategy should identify specific direct and indirect

¹ The Municipal Dischargers are the cities of San Diego, Lemon Grove, and La Mesa, the County of San Diego, and the San Diego Unified Port District.

measurements that they will use to track the long-term progress towards achieving the copper, lead and zinc WLAs required under this TMDL Project. Methods used for assessing effectiveness should include the following or their equivalent: surveys, pollutant loading estimations, and receiving water quality monitoring. The long-term strategy should also discuss the role of monitoring data in substantiating or refining the assessment.

For copper, lead and zinc discharges in urban runoff to or from MS4s within the Chollas Creek watershed, the Municipal Dischargers have an existing obligation under Order 2001-01 to require increasingly stringent BMPs, pursuant to the iterative process described in Receiving Water Limitation C.2.a.² of the Order, to reduce metal discharges in the Chollas Creek watershed to the maximum extent practicable and to restore compliance with the copper, lead and zinc components of the toxic pollutants water quality objectives.

3. Municipal Dischargers and the Navy – Amend Order No. R9-2004-0277, Chollas Creek Investigation and Monitoring Program for Diazinon and Metals

The Regional Board shall amend Order No. R9-2004-0277 to include the following:

A requirement that the Municipal Dischargers and CalTrans to investigate excessive levels of metals in Chollas Creek and feasible management strategies to reduce metal loadings in Chollas Creek. The amendment will require additional monitoring to collect the data necessary to refine the watershed wash-off model to provide a more accurate estimate of the mass loads of copper, lead and zinc leaving Chollas Creek each year.

4. Amend Order No. R9-2000-90, General WDRs for Groundwater Extraction Discharges

The Regional Board will amend Order No. R9-2000-90, which regulates temporary groundwater extraction discharges to San Diego Bay and its tributaries. The effluent limitations for copper, lead, and zinc shall be revised to equal the WLAs for extracted groundwater discharges to MS4s in the Chollas Creek watershed, and directly to Chollas Creek. Regulated groundwater discharges to Chollas Creek must meet the WLAs at the initiation of the discharge. No schedule to meet interim goals will be allowed in the case of groundwater discharges. A revision of the receiving water limitations is not required since they are equal to the WQOs for metals in Chollas Creek.

5. Amend Order No. 97-03-DWQ, Statewide General WDRs for Industrial Facilities Stormwater Discharges

² Receiving Water Limitation C.2.a provides that “[u]pon a determination by either the Copermittee or the Regional Board that MS4 discharges are causing or contributing to an exceedance of an applicable water quality standard, the Copermittee shall promptly notify and thereafter submit a report to the Regional Board that describes BMPs that are currently being implemented and additional BMPs that will be implemented to prevent or reduce any pollutants that are causing or contributing to the exceedance of water quality standards...”

The Regional Board shall request the SWRCB amend Order No. 97-03-DWQ, the statewide general WDRs that regulate stormwater discharges from industrial sites to include the following:

- a. The WLAs and schedule of compliance applicable to industrial facility stormwater discharges into Chollas Creek described in Table 4.*[insert number]*.
- b. A requirement to implement an iterative BMP approach of expanded or better-tailored BMPs to attain the WLAs in Table 11.1 in accordance with the compliance schedule in Table 4.*[insert number]*.
- c. A requirement to submit annual progress reports to the Regional Board on the progress in attaining the WLAs in effluent discharges. The reports shall be due on July 1 of each year and shall be incorporated within the annual report required by section A.14 of Order No. 97-03-DWQ. Reporting shall continue on an annual basis until the metals WQOs are attained and maintained in Chollas Creek.

The report should describe the steps industrial dischargers will take to develop a long-term strategy for assessing the effectiveness of its BMPs. The long-term assessment strategy should identify specific direct and indirect measurements that it will use to track the long-term progress towards achieving the copper, lead and zinc load reductions required by this TMDL. Methods used for assessing effectiveness should include the following or their equivalent: surveys, pollutant loading estimations, and receiving water quality monitoring. The long-term strategy should also discuss the role of monitoring data in substantiating or refining the assessment.

6. Take Enforcement Actions

The Regional Board shall consider enforcement action,³ as necessary, against any discharger failing to comply with applicable waiver conditions, WDRs, discharge prohibitions, or take enforcement action, as necessary, to control the discharge of metals to Chollas Creek, to attain compliance with the metals WLAs specified in this Technical Report, or to attain compliance with the metals WQOs. The Regional Board may also terminate the applicability of waivers and issue WDRs or take other appropriate action against any discharger(s) failing to comply with the waiver conditions.

7. Recommend High Priority for Grant Funds

The Regional Board shall recommend that the SWRCB assign a high priority to awarding

³ An enforcement action is any formal or informal action taken to address an incidence of actual or threatened noncompliance with existing regulations or provisions designed to protect water quality. Potential enforcement actions including notices of violation (NOVs), notices to comply (NTCs), imposition of time schedules (TSO), issuance of cease and desist orders (CDOs) and cleanup and abatement orders (CAOs), administrative civil liability (ACL), and referral to the attorney general (AG) or district attorney (DA). The Regional Board generally implements enforcement through an escalating series of actions to: (1) assist cooperative dischargers in achieving compliance; (2) compel compliance for repeat violations and recalcitrant violators; and (3) provide a disincentive for noncompliance.

grant funding⁴ for projects to implement the Chollas Creek metal TMDLs. Special emphasis will be given to projects that can achieve quantifiable metal load reductions consistent with the specific metal TMDL WLAs.

8. Enroll the Navy in Order No. 2003-0005-DWQ, Statewide general WDRs for Discharges from Small MS4s

Upon receipt of a complete Report of Waste Discharge (ROWD), the Regional Board shall enroll the Navy community facilities of Naval Base San Diego under Order No. 2003-0005-DWQ.

Implementation Monitoring Plan

The dischargers will be required to monitor Chollas Creek and provide monitoring reports to the Regional Board for the purpose of assessing the effectiveness of the management practices implemented to meet the TMDL allocations. Such monitoring is required by Order No. R9-2004-0277.⁵ The Regional Board shall amend that Order to include a requirement that the Municipal Dischargers, and CalTrans investigate excessive levels of metals in Chollas Creek and feasible management strategies to reduce metal loadings in Chollas Creek, and conduct additional monitoring to collect the data necessary to refine the watershed wash-off model to provide a more accurate estimate of the mass loads of copper, lead and zinc leaving Chollas Creek each year.

Schedule of Compliance

Concentrations of metals in urban runoff shall only be allowed to exceed the WLAs by a certain percentage for the first five years after adoption of this TMDL. Allowable concentrations shall decrease by 20 percent each year during this time as shown in Table 4.[insert number]. For example, if the measured hardness in year four dictates the WLA for copper in urban runoff is 10 µg/l, the maximum allowable measured copper concentration would be 14 µg/L. By the end of the seventh year of this TMDL, the WLAs of this TMDL shall be met. This will ensure that copper, lead and zinc water quality objectives are being met at all locations in the creek during all times of the year.

Compliance with the interim goals in this schedule can be assessed by showing that dissolved metals concentrations in the receiving water exceed the WQOs for copper, lead, and zinc by no more than the allowable exceedances for WLAs shown in the table above. Regulated groundwater discharges to Chollas Creek must meet the WLAs at the initiation of the discharge. No schedule to meet interim goals will be allowed in the case of groundwater discharges.

⁴ The SWRCB administers the awarding of grants funded from Proposition 13, Proposition 50, Clean Water Act 319(h) and other federal appropriations to projects that can result in measurable improvements in water quality, watershed condition, and/or capacity for effective watershed management. Many of these grant fund programs have specific set-asides for expenditures in the areas of watershed management and TMDL project implementation for non-point source pollution.

⁵ Order No. R9-2004-0277, *California Department of Transportation and the San Diego Municipal Separate Storm Sewer System Copermittees Responsible for the Discharge of Diazinon into the Chollas Creek Watershed, San Diego, California*.

Table 4. *[insert number]* Compliance schedule and interim goals for achieving Wasteload Allocations

	Allowable Exceedance of the WLAs (allowable percentage above)		
Compliance Year (year after OAL approval)	Copper	Lead	Zinc
1	100%	100%	100%
2	100%	100%	100%
3	100%	100%	100%
4	50%	50%	50%
5	25%	25%	25%
6	10%	10%	10%
7	0%	0%	0%

Appendix K
Scientific Peer Review

Chollas Creek Metals Total Maximum Daily Load

California Regional Water Quality Control Board, San Diego Region

PUBLIC REVIEW DRAFT

28 March 2005

Scientific Peer Review:

“Technical Report for Copper, Lead and Zinc Total Maximum Daily Loads for Chollas Creek, San Diego, Tributary to San Diego Bay”

Garrison Sposito and Jasquelin Peña
Department of Civil and Environmental Engineering
University of California at Berkeley

The draft report under review provides technical information related to the establishment of Total Maximum Daily Loads (TMDLs) for Chollas Creek, an intermittent stream that drains a highly urbanized watershed through two major tributaries in the San Diego area. Outflow from the creek, whose lower reach (see photo of the North Fork, below, taken by J. Peña, March 2005) has impaired water quality, is into San Diego Bay. (Note, however, that the introductory statements on page 4 of the draft report appear to be contradictory in respect to the documentation of impaired water quality, implying that National Toxics Rule criteria are more often exceeded than California Toxics Rule criteria, while calling the latter “more stringent”.) The TMDLs discussed in the report are for the metals, copper, lead, and zinc. As noted in the Introduction of the draft report, TMDLs are load allocations (mass per day) of pollutants to a waterbody, considering both point sources and nonpoint sources, such that the assimilative capacity of the waterbody in respect to applicable water quality objectives is not exceeded.



The methodology followed in the draft report for the three metals of concern is to apply the USEPA- California Toxics Rule (USEPA-CTR) to obtain numeric targets for dissolved metals in Chollas Creek. The dissolved concentrations are calculated for both acute (one-hour average) and chronic (four-day average) conditions from USEPA-CTR statistical regression equations that include factors for site-specific toxicity effects, total-to-dissolved metal concentrations, and direct hardness effects (Table 3.1 in the draft report). Hardness data for the waterbody will be required in order to implement these equations. It is possible to include direct effects of temperature and pH in the equations, but this was not done in the draft report. Site-specific toxicity effects also were not

considered [i.e. Water Effects Ratio (WER) = 1.0 in the regression equations] and the total-to-dissolved metal concentrations ratio for each metal was set equal to a fixed constant for all conditions using the default USEPA-CTR values.

Although the draft report states that the numeric targets set by using the USEPA-CTR equations are a function of hardness, it does not justify why this choice is appropriate for Chollas Creek, other than its legal applicability in California for inland surface waters (draft report, page 11). Reference to CFR 40 Part 131 provides the following guiding commentary on the toxicological significance of hardness-based USEPA-CTR equations:

f. Hardness

Freshwater aquatic life criteria for certain metals are expressed as a function of hardness because hardness and/or water quality characteristics that are usually correlated with hardness can reduce or increase the toxicities of some metals. Hardness is used as a surrogate for a number of water quality characteristics which affect the toxicity of metals in a variety of ways. Increasing hardness has the effect of decreasing the toxicity of metals. Water quality criteria to protect aquatic life may be calculated at different concentrations of hardness, measured in milligrams per liter as calcium carbonate.

Given the importance accorded in the draft report (page 14) to hardness sampling as part of compliance testing, it would be very useful to have more detailed discussion on the relevance of the above paragraph to water quality criteria for the three metals of concern in Chollas Creek.

Although the choice of WER = 1.0 in the draft report is a conservative one, procedures are available from USEPA for evaluating site-specific toxicity effects and modifying the Water Effects Ratio accordingly. This additional information may be of special value in respect to copper because of its strong tendency to form toxicity-reducing soluble complexes with dissolved organic matter. Similarly, the use of a constant total-to-dissolved metal concentrations ratio as given by USEPA is problematic, since the chemical forms of copper, lead, and zinc are likely to vary both spatially and temporally depending on streamflow variation and the changing composition of streamwaters, including suspended load. In the draft report, the assumption is made that the USEPA-CTR default values for the three metals are upper limits of the actual values in Chollas Creek, the implication being that actual total-to-dissolved metal concentrations are always larger than the default values used in the USEPA-CTR regression equations. Since toxicity effect should vary inversely with total-to-dissolved metal concentration, this assumption amounts to an implicit Margin of Safety imposed on the recommended dissolved metal concentrations. An alternative approach would be to evaluate total-to-dissolved metal concentrations as a function of turbidity and include turbidity sampling as a part of compliance testing.

In the usual development of TMDLs for a waterbody, hydrologic data and pollutant source analyses are combined with the numeric targets to calculate waste load and load allocations. However, in the draft report under review, although spatial hydrologic modeling and a very thorough metal source analysis are presented, they are used only to

determine TMDL Critical Conditions (Appendix D, Section 2.2). It appears that most of the data used to develop the TMDLs was collected during stormflows. Additional monitoring during low flow should be implemented since pools of slow-moving or standing water (see photo of Chollas Creek, below, taken by J. Peña) will have very different dynamics—and metal sources—from those associated with high-flow storm events. It is also possible that dissolved metal concentrations during low flow are greater than in the wet season because metal inputs are not diluted by large volumes of rainwater. Also, standing water can undergo evaporation, leading to the concentration of metals in sediments. Some additional minor points to consider in respect to the discussion of metal sources:



Page 32, Section 4.4.5. In the last sentence, the reader should be reminded that this summary applies strictly to the Santa Clara Valley study.

Page 33, Section 4.4.5.2. Quantify the difference between the “back of the envelope calculation” given here and the model results.

Page 37, Section 4.5.4. The percentage of copper contained in each pesticide should be included in Table 4.10.

Because waste load and load allocations were not made, the linkage analysis in the draft report (page 39) consists of identification of the most important metal sources and streamflows to be considered when sampling metal concentration and hardness for assessing compliance with the recommended dissolved metal concentrations. The final recommendations for the three metals are dissolved concentrations equal to 90 % of the dissolved concentrations (i.e. 10 % Margin of Safety) calculated using the USEPA-CTR hardness-based regression equations. These recommended concentrations are compared illustratively to measured concentrations in Appendix G of the draft report. The results in this appendix indicate that maximum observed concentrations of the three metals are significantly greater than the concentrations required to meet water quality objectives, with the discrepancies being much larger at lower hardness values.

The use of dissolved metal concentrations as numeric targets presupposes that the metals do not increase in concentration at higher trophic levels (i.e. no biomagnification) and that they do not accumulate in sediments. Biomagnification of copper, lead, and zinc in test organisms (e.g. daphnia) has not been observed in laboratory studies, insofar as the reviewers are aware, nor is it expected. Biomagnification is associated with hydrophobic pollutants and hydrophobic chemical forms of pollutants (e.g. methyl mercury), whereas most toxic metals have hydrophilic chemical forms in aquatic ecosystems. It is possible that lead could take on a hydrophobic chemical form under anaerobic conditions because it can be methylated by microorganisms, but this is very unlikely in well-aerated waterbodies. Accumulation in freshwater sediments is well established for the three metals of concern, which have strong sorption affinities for natural particles, especially those with organic matter content. The case is made in the draft report that metal concentrations in the creek sediments are typically below levels of probable toxic effect and that particle-bound metals are flushed from the creek within one year by winter flows. These conjectures are not unreasonable, but no database currently exists with which to evaluate them, bringing to mind the important possibility that particle-bound metals transported to San Diego Bay may pose a potential toxicity threat, thus making Chollas Creek a source of this threat.

In summary, the principal points made in this peer review of the draft report are:

Dissolved concentrations of copper, lead, and zinc for acute and chronic conditions calculated from USEPA-CTR regression equations dependent on water hardness are promulgated with a 10 % Margin of Safety instead of TMDLs, which typically combine allowable dissolved metal concentrations with hydrologic and metal source analyses to prescribe mass loadings that meet applicable water quality objectives.

Detailed scientific justification of the USEPA-CTR hardness-based equations for applicability to Chollas Creek waters in determining allowable metal concentrations is not provided. However, assumptions of no metal biomagnification or accumulation in sediments, which underlie the use of numeric targets based on dissolved concentrations, seem justified.

Compliance testing guided by TMDL Critical Conditions will require measurements of both metal concentrations and hardness (as calcium carbonate) for use with USEPA-CTR regression equations that, along with the 10 % Margin of Safety, define the numeric targets. Preliminary calculations indicate that current metal concentrations in Chollas Creek are in excess of these targets, particularly at low hardness values.

Hydrologic modeling and metal source analyses are used to select TMDL Critical Conditions for compliance testing. Hydrologic modeling is not explicitly used in metal load and wasteload allocations. All hydrologic and metal source effects are implicit in these allocations.

The current database for Chollas Creek can be improved by additional monitoring of both metal concentrations during lowflow periods and metal accumulation in creek sediments that may serve as a source of contamination for San Diego Bay. Additional laboratory toxicity testing using Chollas Creek waters would be useful in order to justify the Water Effects Ratio and to evaluate the accuracy of the default total-to-dissolved metal concentration factor assumed in the USEPA-CTR regression equations.

Peer Review Comments from Dr. Joseph Shaw Dartmouth College

Response to: **Request for scientific peer review of the technical portion of the amendment incorporating the copper, lead, and zinc total maximum daily loads for Chollas Creek into the water control plan for the San Diego basin.**

I commend the California Regional Water Quality Control Board, San Diego Region for their efforts to reduce the loads of copper, lead, and zinc entering the Chollas Creek Watershed by ~50-70% (e.g., depending on metal). The technical report presents a conservative approach to establishing Total Maximum Daily Loads (TMDL) for the three metals that are required to meet the established water quality standards. Given the paucity of data in certain instances this conservative approach, which was based on concentrations derived from California Toxic Rule requirements (U.S. EPA, 2000) for these metals and source/land use models to predict load, was warranted. It should be noted that cautionary/critical statements in this review are provided as an aid to strengthen the scientific portion of the proposed rule. It is my opinion that the current draft of the technical plan far surpasses the status quo (i.e., not implementing the TMDL). Comments to specific questions are given below.

1) Biomagnification potential for copper, lead and zinc:

“Copper, lead and zinc may biomagnify in aquatic life in Chollas Creek. The California Regional Water Quality Board, San Diego Region (Regional Board) believes that these metals do not biomagnify. We would like to know if we have sufficiently justified this position and if there are substantive arguments to the contrary.”

As stated in the TMDL, there is little evidence that copper, lead and zinc biomagnify in top-level feeders. However, I question whether one sentence in Section 2.4 (p.8) that cites a single 20 year old reference (Moore and Ramamoorthy, 1984) from a book on organic chemicals sufficiently justifies this position. Appropriate citations would include Timmermans et al., 1989; Suedel et al., 1994; Jarvinen and Ankley, 1999; and Besser et al., 2001. Also, there is growing evidence that zinc and to some extent copper can biomagnify within aquatic food webs (Quinn et al., 2003; Chen et al., 2000; Timmermans et al., 1989). However, these studies focused on lower food chain levels (i.e., phytoplankton, zooplankton, macro-invertebrates) and evidence extending these findings to higher trophic-level consumers (e.g., birds and mammals) is unfounded.

2) Copper, lead, and zinc accumulation in creek sediments:

“The Regional Board has reviewed the available data and concluded that copper, lead, and zinc are not a problem in the sediments of Chollas Creek. We would like to know if we have scientifically and sufficiently supported this claim.”

Sediment accumulation of metals in Chollas Creek appears to be minor (Table 2.4; Appendix C). The PEL (probable effect level; more recently termed PEC, probable effects concentration, MacDonald et al., 2000) approach has been successfully used to screen sediments on both a regional and national basis (Ingersoll et al., 2001). However, there are a couple of points of caution to be made with interpreting data provided (Table 2.4, Appendix C). As indicated in the text, PELs represent concentrations where toxicity (adverse effects) is expected to occur frequently. The water quality objective (*“All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.”*) is more strict, seeking to protect against toxicity, not just frequent toxicity. With this in mind, cadmium although rarely detected (11 of 81

samples) and detected in excess of PEL (1.2%), has an average concentration that approaches PEL. Also, the one time it exceeded PELs it did so by over 6.5 fold. However, it is difficult to draw conclusions about this site, since it was only sampled once. In fact, the bulk of the sampling within the creek (sampling designated 978-270 to 978-337) occurred at a single time point and no temporal replication of these sites is shown. The data set that includes temporal replication contains three sites within San Diego Bay and only one site within the creek (location not provided). Given the short residence time of the sediments within the creek (~1 year as given in Section 2.5), a single grab from 1998 could be dramatically different from 2005. For the PEL screening approach to be successful the data being screened needs to adequately reflect that of the creek. Also, as pointed out in this document (section 2.4), metal toxicity has a strong relationship with speciation. Total sediment metal concentrations (just as measurements of total metal in the water column) have proven problematic in assessing toxicity. Typically sediment metal concentrations are discussed in context of sediment characteristics such as grain size, organic carbon, simultaneously extracted metal:acid volatile sulfides ratio, pH, etc.

3) Selection of Numeric Targets:

“Numeric Targets must be appropriately chosen to ensure the attainment of the Water Quality Standards (Water Quality Objectives, Beneficial Uses and Anti-degradation Policy) of the Creek. It is expected that the used of the CTR objectives as Numeric Targets will lead to the protection of the WARM and WILD beneficial uses of the creek. However, CTR may not be protective of all species protected under these two beneficial uses. The Regional Board would like to know if the choice of Numeric Targets to protect the beneficial uses is bases upon sound scientific knowledge, methods, and practices. The regional Board would also like to know if there are other objectives that are also/more appropriate.”

CTR criteria are set to protect aquatic-life in California water bodies against both acute and chronic exposures to harmful contaminants. These include hardness corrections for ambient copper, lead, and zinc standards, an approach that has been incorporated in U.S. EPA ambient water quality criteria for the protection of aquatic-life for over 20 years (including updates). The hardness corrections account for the (generally) protective effect of the two components of hardness (i.e., calcium, magnesium) on the toxicity of these metals. In the absence of site specific water quality parameters and species inventory lists for Chollas Creek, such an approach represents the most conservative and scientifically defensible action. However, there are some points of caution with their application. Criteria are designed to protect 95% of the species that fall within the range of sensitivities of those that were tested as part of the criteria development process. For acute criteria, these are generally robust and although a species inventory is not provided for Chollas Creek such targets would be expected to be protective of most species present. However, chronic criteria are established using a much smaller range of species through the development of acute to chronic ratios that are more broadly applied. For these reasons, chronic criteria would stand to be more impacted by site specific parameters. If data are present on the species residing in Chollas Creek it could really benefit application of CTR standards. Also, it is surprising that hardness data, while admittedly variable, are not provided. I agree that because of the temporal/seasonal variability of Chollas Creek that it is appropriate to present hardness dependent standards. However, information on hardness would be a useful addition to the Technical Report as a means of determining the current status of Chollas Creek. Also, these standards are less predictive at the lower and higher extremes for hardness (Gensemer et al., 2002), where other water quality parameters can have a greater influence on toxicity. Finally, I would like to compliment the authors of this report for their inclusion of the newly proposed Biotic Ligand Model (Paquin et al., 2002) for copper and support their position of revisiting Numerical Targets if/when these are adopted. The BLM represents a fundamental change in the way metals criteria are calculated that models metal binding to critical biotic ligands, such as the fish gill, and relates this metal burden to detrimental effects on the organism. While they are more inclusive of mitigating water quality parameters, they are more data intensive (e.g., requiring simultaneous measurements of copper and many complexing anions and competing cations).

4) Sampling requirements to assess Loads and Waste Load Allocations:

“The Regional Board has designated sampling requirements to evaluate the Load and Waste Load Allocations and would like to know if they are sufficient, appropriate, and based upon sound scientific knowledge, methods, and practices. The question really deals with spatial and temporal scales. Given the size of the creek and the seasonal variability of its flow, it will be key to select measurement sites and frequencies that will allow assessment of the attainment of the Load and Waste Load Allocations through the year and throughout the entire creek system.”

There is insufficient material available regarding the spatial and temporal aspects of the monitoring/sampling plan to comment on its usefulness in assessing Load and Waste Load allocations for the Chollas Creek Watershed. In the absence of designating sampling requirements, it would be appropriate and necessary at a minimum to provide guidance on the development of such a plan in the Technical Report.

5) Water Effects Ratio:

“A Water Effects Ratio (WER) is part of the CTR Equation for establishing water quality criteria for copper, lead, and zinc. However, sufficient data are not available to modify the default WER value of unity (with the proposed Numerical Target). The Regional Board would like the reviewer to comment on the state of use of WERs in the freshwater systems.”

Water effects ratios provide a way to calibrate numerical targets to site-specific conditions. These include endogenous species and/or water quality parameters that may vary from those used to develop the standard in sensitivity and influence on toxicity, respectively. These are typically derived after extensive on-site testing and are usually initiated by regulated parties. This approach (*i.e., making unity the WER default and letting the regulated community establish site-specific conditions under the guidance of the Regional Board*) is reasonable, especially given that WER are often implemented to make conservative Numerical Targets less restrictive. As discussed above for numerical targets, acute criteria are influenced less by site specific conditions (*i.e., WER close to unity*; Cherry et al., 2002). Cherry et al. (2002) established a site specific CMC for copper in the Clinch River, VA. This required a battery of toxicity tests conducted using 17 genera native to or currently residing in the river that were not part of the derivation of the Final Acute Value (FAV) used in the current U.S. EPA regulations. They concluded that the site specific CMC was not substantially different than the national copper criteria. They suggested site-specific adjustments would be most meaningful for criteria developed to protect against chronic exposures and low-level impact. I could find no published reports detailing successful integration of site-specific numerical targets using a WER approach.

It should be noted that one additional source of site-specific variability could easily be incorporated into the TMDL. Direct measurements of dissolved metals can be influenced by a number of parameters and the use of conversion factors to translate total metal concentrations into dissolved is somewhat arbitrary and likely not reflective of the specific chemistries found within the watershed. It would seem reasonable to require that the monitoring plan require dissolved metals to be measured.

6) Source Analysis:

“The Regional Board must adequately estimate the sources of the metals to the creek. The Regional Board would like the reviewer to comment on the science, methods, and practices used to estimate the sources of copper, lead and zinc. The analysis of the sources is key to successful implementation of reduction schemes. Therefore, it is critical to address all sources of metals and to make some type of

estimate of their total load to the creek. This was accomplished through a model based upon land uses and build-up/wash-off coefficients. Other sources were identified by reference to available literature that identify metal sources in other urban areas.”

The methods or literature used to determine that the majority of run-off entering Chollas Creek is via the storm water conveyance system (MS4s, Section 4, introduction, p. 15) are not clearly stated. It makes sense given that there are no other point sources, but the reader is left to make the assumption that direct run-off into the creek is negligible (i.e., both volume and source). This is a crucial point as it identifies/acknowledges the jurisdiction of NPDES WDR and I think a citation or further explanation of this determination is warranted, especially since it places the load responsibility on 20 sources identified through NPDES permit requirements (Section 4.1, pp. 15-16). It would seem a mass accounting of volume entering via storm water conveyances and exiting the creek was used, but this was not mentioned. This conclusion also makes sense empirically because a direct link between stormwater discharges and creek toxicity has already been established (Schiff, 2001). Given that stormwater is the major source of load input for Chollas Creek, the paradigm of identifying sources and modeling land-use specific loads for MS4s is reasonable. Additional comments on load estimates and source identification are given below (Questions 7-10).

7) Land Use Model:

“The Regional Board would like the reviewer to comment on the adequacy of the Source Analysis model description found in Appendix D. The model provides the basis of the Source analysis and was run by Tetra Tech, Inc. The Regional Board merged the Tetra Tech document with literature from the U.S. EPA (BASINs manual) and other sources in an effort to create a document (Appendix D) more accessible to the layperson. Please comment on the adequacy of Appendix E in its description of the model.”

As a non-modeler I found the model description in Appendix D accessible. It did a great job explaining the process of data acquisition, populating model parameters, calibration, and independent validation, which are critical for model development. It also was effective in conveying the strengths, weaknesses, and limitations of the models, especially with regards to data gaps/needs and appropriate/inappropriate applications.

8) Model Interpretation:

“The Regional Board would like the reviewer to comment on the scientific basis of the interpretation of the model results and deficiencies. Since the model was produced by an outside consultant, the Regional Board would appreciate the reviewer’s opinion on the findings and limitations of the model used as the basis for the Source Analysis.”

The immediate deficiencies are obvious; lack of input data (especially water quality measurements during dry weather conditions). Given these limitations it is difficult to assess the models performance. While it has potential to estimate metal concentrations in the Creek or support load allocations across varying condition, these identified deficiencies limited its application to identifying potential sources to target for load reductions. While this is useful it has less direct bearing on the derivation of the TMDL. As noted in Section 4, when data are sufficient they could be readily incorporated into the model.

9) Source Analysis Literature:

“The Regional Board would like the reviewer to comment on the scientific basis of applying results from studies of other urban areas to the Chollas Creek watershed. There are no known peer-reviewed studies describing sources of metals to Chollas Creek, nor is there much information about metal sources in the

greater San Diego area. Therefore, studies detailing metals sources in other urban areas served as the basis for part of the Source Analysis discussion. Some of the studies come from other highly populated cities in California, while others come from urban centers in other parts of the world. While certain land use practices are similar between all these areas, other controlling factors (climate, geology, local ordinances, social attitudes, etc) are likely to be much different. Therefore, these studies must be referenced in a conservative manner and not over extrapolated. Please comment on whether or not this boundary has not been breached.”

The application of results from other studies to Chollas Creek is no different than most any discussion section found in a peer-reviewed article where the objective is to discuss results (strengths and weaknesses) in context of the body of existing literature. In this sense, such an approach seems not only warranted, but also mandated. I found the literature selections for comparisons justified in terms of similarities (i.e., the most similar studies were selected). Similarities included geographical proximity, population size, land-use, policy, etc. However, in all cases differences and their potential to influence interpretations were highlighted. The only reference I question is the inclusion of Brown and Caldwell, (1984), which was used in section 4.4.2, p. 31. While its limits were clearly noted, the inclusion of lead loading data prior to the CAA ban of lead and lead additives in gasoline provides little area for comparison.

10) Data Deficiencies:

“The available data for Chollas Creek is not as complete as desired. The Regional Board would like the reviewer to comment on whether or not data gaps have been adequately identified, particularly in the Source Analysis and in the Linkage Analysis sections. In particular, the model lacked site-specific flow data for validation and sufficient dry weather information for even a model run. These data gaps must be thoroughly discussed to ensure transparency of the document and to identify necessary monitoring areas under the Implementation Plan. Additionally, data gaps may weaken the connection between the allocations and the attainment of the Water Quality Standards.”

The largest data gap I have found for the entire document deals with the lack of information pertaining to a monitoring plan. This is critical to fulfill one of the necessary requirements of Linkage Analysis (i.e., providing the quantitative link between the TMDL and attainment of WQSs) and does not seem to be appropriately identified (SEE RESPONSE TO QUESTION 4). Another unidentified gap appears in Section 5 (Linkage Analysis, p. 39) which states that the technical report is required to “estimate the total assimilative capacity (loading capacity) of Chollas Creek for the metals and *describe the relationship between Numeric Targets and identified metal sources.*” I found no description of the later in this section. Also, as stated above it is a little unclear the role the model is serving (i.e., how it will be applied) in the TMDL development. Perhaps, I’m missing something, but it seems a little anticlimactic after reading section 4 and Appendix D that describe the model to get to the Linkage Analysis Section only to discover it has little application to TMDL development.

11) Synergistic Toxicity:

“The Regional Board is not aware of any synergistic toxicity effects associates with dissolved copper, lead, and zinc in the water column and has written this TMDL accordingly. Please comment on the scientific basis for this approach. If all three metals are present at just under their allowable CTR concentration, the water may still not be safe for aquatic life. It is possible that these three metals could work together to form a toxic condition...The Regional Board would like the reviewer to comment on the scientific basis for the potential for a synergistic effect with another chemical pollutant. If an interaction is likely, please comment on the scientific impacts to the Load and Waste Load Allocations. If the metals

Cu, Pb, and Zn are synergistic in their toxic effect on freshwater organisms, perhaps an additional margin of safety should be considered.”

There is evidence for synergistic (i.e., greater than additive) and additive (which could also produce scenarios described above) effects of binary mixtures of copper and zinc and lead and zinc (Kraak et al., 1993; Franklin et al., 2002; Utgikar et al., 2004). However, published reports include laboratory studies that have focused on lower trophic levels (i.e., bacteria, phytoplankton, zooplankton). None of these studies investigated concentration ranges applicable to chronic effects and for the most part they focused on binary rather than more complex mixtures. It should be noted that mixture toxicity can be difficult to assess even in the laboratory as results (i.e., antagonism, additive effects, synergism) can vary with species, strain, concentration, and other parameters (Franklin et al., 2002, Borgmann et al., 2003, and numerous others). For example, Martinez et al. (2004) in studies with *Chironomus tentans* found lead and zinc to interact antagonistically to produce sub-chronic/population level effects (i.e., mouth part deformities), which is opposite from the studies cited above. This question could be pertinent, but does not appear to have been addressed in the de-listing of cadmium. There are numerous studies detailing interactive effects of cadmium combined with zinc, lead, and copper. Again, observed effects range from synergism to antagonism, but evidence exists for the scenario raised above where metals are present below the CTR concentrations and interact in a synergeistic (or depending on concentration in an additive) manner to produce toxicity (Beisenger et al., 1986; Kraak et al., 1993; Jak et al., 1996; Barata et al., 2002; Franklin et al., 2002). The CTR Numerical Targets are derived for individual chemicals and do not account for mixtures. However, given the variability in the nature of interactions reported for these metals, interactions would be difficult to regulate in the absence of site-specific data. In summary, I would conclude that while some evidence for metal interactions exists, appropriate determinations of effects would need to include site specific variables in order to be scientifically defensible. The BLM if/when it is adopted could eventually provide a means of dealing with metal mixtures (Paquin et al., 2002; Niyogi and Wood, 2004; Playle, 2004).

12) Linkage Analysis:

“The Linkage Analysis must adequately establish the link between the Load and Waste Load Allocations and the attainment of Water Quality Standards. Please comment on the scientific basis for the linkage provided in this TMDL. This is similar to number 3 above. The ultimate goal of the TMDL is to restore and protect the Water Quality Standards of Chollas Creek that are being degraded by Cu, Pb, and Zn. The Load and Waste Load Allocations must be calculated to achieve this goal. Therefore, they are the critical component of the technical discussion and must be thoroughly scrutinized. Furthermore, the Linkage Analysis must sufficiently establish this connection.”

The Waste Load and Load allocations are directly linked to Water Quality Standards defined by the numerical limits, as they are identical. The decision was made by the Board to take a conservative (i.e., from the protection standpoint) approach and set load allocations based on concentration rather than mass. In other words, it is not the relative amounts (i.e., mass) of metals, but rather their respective concentrations that determine load and load reductions will be based on maintaining concentrations of metals at or below these concentration based targets (the exact concentration is fluid and depends on the water hardness). This approach seems reasonable given the dynamic nature of the system. There is one peer-reviewed study and at least one technical report that link effects of storm water drainage and more specifically the metal component of this drainage to toxicity in aquatic-life in Chollas Creek and the portions of San Diego Bay it enters (Schiff et al, 2001; 2003). Since the load allocations are identical to the numerical limits my response to question 3 is also applicable here.

13) Margin of Safety:

“The Margin of Safety (MOS), both implicit and explicit, incorporated in the TMDL should be of a reasonable magnitude to account for uncertainty. Please comment on the scientific foundations and adequacy of the Margin of Safety incorporated into this TMDL. A MOS is a required component of the allocations. It is designed to account for any uncertainty in the calculations supporting the Load and Waste Load allocations. Please comment on the scientific foundations and adequacy of the Margin of Safety incorporated into this TMDL.”

The explicit 10% MOS incorporated into the TMDL represents a commonly employed safety factor. The 10% load correction is to guard against the uncertainty inherent in the Source Analysis and Linkage Analysis; differences between total and converted dissolved metal concentrations; and site-specific differences in CTR derived Numerical Targets. It is difficult to comment on the appropriateness (or scientific validity) of the 10% correction. There was greater than 10% variability in measured metal concentrations (Table 2.1). Some explanation for the rationale behind the 10% MOS would be helpful. In addition, there are implicit MOS that stem from using measured rather than estimated hardness values to calculate the TMDL. Likewise, as discussed below, the CTR values incorporate 50% correction.

I didn't understand the argument provided in the last paragraph of section 6 (p. 41). Metal interactions were discussed in question 11 above. There are numerous explanations for interactive effects, which have been observed for copper, lead, and zinc. For example, common uptake routes (e.g., calcium channels for cadmium and zinc) or distributions and detoxications could account for interactive effects. While speciation affects toxicity, biological processes have also been shown to influence interactions during laboratory tests conducted under identical water chemistries. Perhaps chemical interactions refers to complexation with anions and negatively charged sites on particulates, which would reduce bioavailability. Anyway, this paragraph/point could use clarification.

14) California Toxics Rule Inherent Margin of Safety:

“The California Toxics Rule formulas provide conservative water quality criteria that are protective of aquatic life. However, since the equations are based upon available laboratory data, they may not be protective of all aquatic life in Chollas Creek and an additional MOS has been added to the TMDL. Please Comment on the scientific basis of this approach...Criteria are based only upon available toxicity testing that may not be available for all taxonomic groups. Does this danger warrant the need for an additional 10% MOS as addressed in number 12 above?”

As stated above, the one peer-reviewed manuscript that described formulating site-specific CMC for copper concluded that including over 17 sensitive site-specific species to calculate the FAV did not significantly lower the CMC (Cherry et al., 2002). Also, the CTR are based on national ambient water quality criteria, for which the science has been validated through several updates over 20 years. It wasn't until recently that new approaches (i.e., BLM) gained favor. Given the defensibility and robustness of this approach coupled with the lack of evidence for extreme site-specific sensitivities another 10% MOS does not seem warranted.

15) Critical Conditions:

“The Regional Board has addressed seasonal variations and critical conditions by the use of the CTR formulas that incorporate site and time-specific hardness and metal concentration data. Please comment on the scientific basis and adequacy of this approach. This TMDL is designed to be protective of the creek in all weather and flow conditions during all times of the year. It is believed that the use of the CTR equations will adequately apply the Load and Waste Load Allocations on a temporal and spatial specificity to ensure this protection at all times. By comparing each instream metal concentration against its appropriate criteria calculated from the hardness measured at the same time and location, the Load and Waste Load Allocations will be a moving target that accounts for ecosystem variability.”

The use of a concentration (mass/volume) based TMDL negates effects of variable flow on load allocations, since regardless of the amount (mass) of metals that are present, it is the CTR derived concentrations that must be maintained. Concentration based criteria have a long history of use and even the newly proposed BLM, which relate an amount of metal bound to a critical biotic ligand to toxicity, are still expressed as concentrations. The use of concentrations is an appropriate approach for Chollas Creek given the limited data available for Land Use Models and other methods used to estimate the metal load entering during wet and dry periods. Likewise, the use of CMC and CCC targets ensure critical exposure conditions (acute, chronic) are incorporated. Furthermore, the inclusion of measured rather than estimated hardness concentrations reduce seasonal variability, especially during critical conditions. Provisions are also made to revisit other stream chemistry parameters that were not included in this TMDL if/when the BLM for copper is adopted. Collectively, these measures stabilize the TMDL even over extreme/critical conditions that could be occurred within the basin.

16) Overarching issues:

“Reviewers are not limited to addressing only the specific issues presented above, and are asked to contemplate the following “big picture” concerns.

- a. In regarding the staff technical report and proposed implementation language, there may be additional scientific issues that are part of the scientific basis of the proposed rule that are not described above. If so, please comment with respect to the statute language given above.*
- B. Taken as a whole, please comment on the scientific knowledge, methods, and practices that constitute the scientific portion of the proposed rule.*

Reviewers should also note that some proposed actions may rely significantly on professional judgment where available scientific data are not as extensive as desired to support the statute requirements for absolute scientific rigor. In these situations, the proposed course of action is favored over no action.”

With regards to additional scientific issues relating to the Technical Report, there was little mention of specific methods, especially for metal sampling and analysis. Most every question in this reviews asked the reviewer to comment on the scientific methods, so it would appear to be information useful this review. Inclusion of methods could be done in the form of references, but I think their inclusion in necessary to ensure appropriate sampling/measurement techniques are employed and thus, TMDLs are meaningful.

Specific comments regarding the Technical report are as follows:

Attachment 1, p. 1, second paragraph- There are more appropriate references than More and Ramamoorthy, 1984).

Technical Analysis, p.1, 1st paragraph, 1st sentence- insert 'and a' between County and tributary.

“ “, p. 1, 1st paragraph, with regards to de-listing Cd, see question regarding synergistic effects above.

Problem statement, p. 2, in the 1st paragraph inconsistencies with the use of lower and lowest.

“ “, same paragraph- Ceriodaphnia is misspelled.

“ “, same paragraph- not exactly clear on the use of the sea urchin. I assume this is from test of Bay water? Also, in general toxicity data were not presented in clearly.

Section 2.3, p. 8, 2nd paragraph, last sentence; it states that compliance shall be evaluated using a 96-hr acute bioassay. The Daphnia tests mentioned are 48-h tests.

Section 2.4., p. 8, 1st paragraph, poor reference for biomagnification of metals.

“ “, toxins are natural compounds (i.e., snake venom, ammonia); toxicants is the appropriate word here.

“ “, Next sentence; ...same locations more commonly found at higher concentrations in

“ “, P. 9, Better references than Buffle, 1989.

“ “, P. 9, 2nd paragraph, last sentence, Unclear what is being referred to where the implementation plan is located?

Section 2.6. p. 10. In reference to the monitoring site, it is stated that this sampling station is representative of the entire watershed. How was this determination made?

“ “, next paragraph. Replace 1994.95 with 1994-95.

“ “, Same paragraph. Provide methods for toxicity tests.

“ “, Same paragraph. Sentence that states, “Reproduction of the water fleas was generally note impaired, even in individuals that died later in the test.” Is not clear.

Section 3, Numeric Targets, 1st paragraph. Reference the EPAs Metal Translator or whatever the source of the conversion factors was.

“ “, Same page, last paragraph, States that the targets given in table 3.1 were derived to be protective of marine aquatic life from toxicity. Should it read 'freshwater' aquatic life?

“ “, p. 12, Equation 3.2; Where: make sure subscripts agree with acute target. I think they should be A instead of C. This also needs correcting in the descriptive sentence to follow.

Section 3.2, Water Effects Ratios. 1st paragraph, 1st sentence, delete more

“ “. Last sentence. I would remove reference to the appendix if it will not be included.

Section 3.6. last sentence. Replace biochemical with biotic. (the gill is not a biochemical stie)

Section 4.2.1.1. add period between next to last and last sentence.

Section 4.3. p. 28. 2nd paragraph. Replace Creeks with Creek

Section 4.3.2. p. 31. 1st paragraph. I don't think the argument is strengthened with the inclusion of the 1984 lead reference (SEE Comments above.).

Section 4.4.3. p. 31. second sentence. Replace do with low.

In addition, there are a number of mis-labelings in the appendices

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Appendix L

Response to Peer Review Comments

Chollas Creek Metals Total Maximum Daily Load

California Regional Water Quality Control Board, San Diego Region

PUBLIC REVIEW DRAFT
28 March 2005

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RESPONSE TO PEER REVIEW COMMENTS

Response to Peer Review Comments from Dr. Joseph Shaw

1. Overall Assessment by Dr. Shaw

Comment

It should be noted that cautionary/critical statements in this review are provided as an aid to strengthen the scientific portion of the proposed rule. It is my opinion that the current draft of the technical plan far surpasses the status quo (i.e., not implementing the TMDL).

Response

Comment noted.

2. Biomagnification of Metals

Comment

As stated in the TMDL, there is little evidence that copper, lead and zinc biomagnify in top-level feeders. However, I question whether one sentence in Section 2.4 (p.8) that cites a single 20 year old reference (Moore and Ramamoorthy, 1984) from a book on organic chemicals sufficiently justifies this position. Appropriate citations would include Timmermans et al., 1989; Suedel et al., 1994; Jarvinen and Ankley, 1999; and Besser et al., 2001. Also, there is growing evidence that zinc and to some extent copper can biomagnify within aquatic food webs (Quinn et al., 2003; Chen et al., 2000; Timmermans et al., 1989). However, these studies focused on lower food chain levels (i.e., phytoplankton, zooplankton, macro-invertebrates) and evidence extending these findings to higher trophic-level consumers (e.g., birds and mammals) is unfounded.

Response

Our intention was not to justify the conclusion that copper lead and zinc do not bioaccumulate in Chollas Creek based on the Moore and Ramamoorthy reference. Section 3.4 (formerly 2.4) of the Technical Report states: “Copper, lead and zinc may bioaccumulate within lower organisms, yet they do not biomagnify up the food chain as do mercury and selenium ...”. This sentence implies that mercury and selenium have a higher potential for biomagnification over copper, lead, or zinc. The technical report does not state that copper, lead, or zinc will not bioaccumulate but rather the potential for biomagnification is more likely for mercury and selenium when compared against the other three metals.

There are no site-specific studies on Chollas Creek to verify whether metals are bioaccumulating into higher trophic level consumers. However, studies have been completed on marine sediments at the mouths of Chollas and Paleta Creek where they enter into San Diego Bay. Laboratory bioaccumulation sediment studies were

conducted at 7 locations in the Chollas Creek channel and 7 locations in the Paleta Creek channel using the clam *Macoma nasuta*. The results from the 28-day bioaccumulation tests indicate a slightly higher bioaccumulation potential for copper and lead when compared to the reference mean tissue concentrations (RWQCB 2004).¹ Mean tissue concentrations for mercury and zinc were comparable to the tissue levels observed in the reference tissue.

Assuming Chollas Creek discharge contributes to the metals found in the sediment in the Chollas Creek channel, the preliminary study indicates a potential might exist for some metals that originated in the creek to reach higher trophic level consumers.

An additional reference has been included in the Technical Report to further support the position that copper, lead and zinc are not expected to biomagnify. Furthermore, the first paragraph of section 3.4 has been changed to:

Copper and zinc are essential elements for all living organisms, but elevated levels may cause adverse effects in all biological species. Lead is presumed to be a non-essential element for life; more importantly, even at extremely low environmental concentrations this element may create adverse impacts on biota. Dissolved forms of these metals are directly taken up by bacteria, algae, plants and planktonic and benthic organisms. Dissolved metals can also adsorb to particulate matter in the water column and enter aquatic organisms through various routes. Copper, lead and zinc may bioaccumulate within lower organisms, yet they are not expected to biomagnify up the food chain as do mercury and selenium (Moore and Ramamoorthy, 1984). The issue of biomagnification is still being debated among the scientific community (Besser, et al, 200) and cannot be assessed in Chollas Creek with the available information. Of all of these metals, copper is considered the most potent toxicant at environmentally relevant aqueous concentrations. Copper is more commonly found at higher concentrations in herbivorous fish than carnivorous fish from the same location (USF&W, 1998). Copper is used as an aquatic herbicide to reduce algae growth in reservoirs and also applied (via antifouling paints) to boat hulls in marinas.

3. Creek Sediment

Comment

Sediment accumulation of metals in Chollas Creek appears to be minor (Table 2.4; Appendix C). The PEL (probable effect level; more recently termed PEC, probable effects concentration, MacDonald et al., 2000) approach has been successfully used to screen sediments on both a regional and national basis (Ingersoll et al., 2001). However, there are a couple of points of caution to be made with interpreting data provided (Table 2.4, Appendix C). As indicated in the text, PELs represent concentrations where toxicity (adverse effects) is expected to occur frequently. The water quality objective ("All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses

¹ RWQCB 2004. Sediment Assessment Study for the Mouths of Chollas and Paleta Creek, San Diego. Phase 1 Draft Report. Southern California Coastal Water Research Project and Space and Naval Warfare Systems Center San Diego, United States Navy – San Diego. September 2004.

in human, plant, animal, or aquatic life.”) is more strict, seeking to protect against toxicity, not just frequent toxicity. With this in mind, cadmium although rarely detected (11 of 81 samples) and detected in excess of PEL (1.2%), has an average concentration that approaches PEL. Also, the one time it exceeded PELs it did so by over 6.5 fold. However, it is difficult to draw conclusions about this site, since it was only sampled once. In fact, the bulk of the sampling within the creek (sampling designated 978-270 to 978-337) occurred at a single time point and no temporal replication of these sites is shown. The data set that includes temporal replication contains three sites within San Diego Bay and only one site within the creek (location not provided). Given the short residence time of the sediments within the creek (~1 year as given in Section 2.5), a single grab from 1998 could be dramatically different from 2005. For the PEL screening approach to be successful the data being screened needs to adequately reflect that of the creek. Also, as pointed out in this document (section 2.4), metal toxicity has a strong relationship with speciation. Total sediment metal concentrations (just as measurements of total metal in the water column) have proven problematic in assessing toxicity. Typically sediment metal concentrations are discussed in context of sediment characteristics such as grain size, organic carbon, simultaneously extracted metal: acid volatile sulfides ratio, pH, etc.

Response

The text in section 3.5 has been updated to include the Probable Effect Concentration (PEC) and references the 2000 paper by MacDonald et al.

The Regional Board agrees with Dr. Shaw that a sediment metal concentration at or below the PEL or PEC could be interpreted to be in violation of the more stringent water quality objective for toxicity (see Section 3.3). However, the toxicity objective is more appropriately applied to the water column. Unfortunately, neither the State of California nor the United States Environmental Protection Agency (USEPA) have objectives nor standards that are directly applicable to freshwater sediment metal concentrations. Until such criteria are promulgated, the interpretation of sediment metal concentrations must rely on screening values or some statistically based threshold, such as the PEL or PEC.

The average sediment concentration of cadmium in Chollas Creek is approximately 2.1 mg/kg (dry weight). This is approximately 40 percent below the PEL of 3.53 kg/mg (dry weight). Furthermore, cadmium sediment concentrations only exceeded the PEL in one out of 81 samples over a 7-year period and only 11 of those 81 samples even had detectable cadmium concentrations. While mean and median sediment cadmium concentrations are much closer to the PEL than copper, lead or zinc, cadmium still warrants removal from the Clean Water Act 303(d) List of Water Quality Limited Segments (see the response to Comment 12 for further discussion on the delisting).

If subsequent information indicates that sediment may be a contributor to water column toxicity, the Regional Board will consider revising the monitoring

requirements to include cadmium, grain size, organic carbon, simultaneously extracted metal to volatile sulfide ratios and pH.

4. Numeric Targets

Comment

CTR criteria are set to protect aquatic-life in California water bodies against both acute and chronic exposures to harmful contaminants. These include hardness corrections for ambient copper, lead, and zinc standards, an approach that has been incorporated in U.S. EPA ambient water quality criteria for the protection of aquatic-life for over 20 years (including updates). The hardness corrections account for the (generally) protective effect of the two components of hardness (i.e., calcium, magnesium) on the toxicity of these metals. In the absence of site-specific water quality parameters and species inventory lists for Chollas Creek, such an approach represents the most conservative and scientifically defensible action. However, there are some points of caution with their application. Criteria are designed to protect 95% of the species that fall within the range of sensitivities of those that were tested as part of the criteria development process. For acute criteria, these are generally robust and although a species inventory is not provided for Chollas Creek such targets would be expected to be protective of most species present. However, chronic criteria are established using a much smaller range of species through the development of acute to chronic ratios that are more broadly applied. For these reasons, chronic criteria would stand to be more impacted by site-specific parameters. If data are present on the species residing in Chollas Creek it could really benefit application of CTR standards. Also, it is surprising that hardness data, while admittedly variable, are not provided. I agree that because of the temporal/seasonal variability of Chollas Creek that it is appropriate to present hardness dependent standards. However, information on hardness would be a useful addition to the Technical Report as a means of determining the current status of Chollas Creek. Also, these standards are less predictive at the lower and higher extremes for hardness (Gensemer et al., 2002), where other water quality parameters can have a greater influence on toxicity. Finally, I would like to compliment the authors of this report for their inclusion of the newly proposed Biotic Ligand Model (Paquin et al., 2002) for copper and support their position of revisiting Numerical Targets if/when these are adopted. The BLM represents a fundamental change in the way metals criteria are calculated that models metal binding to critical biotic ligands, such as the fish gill, and relates this metal burden to detrimental effects on the organism. While they are more inclusive of mitigating water quality parameters, they are more data intensive (e.g., requiring simultaneous measurements of copper and many complexing anions and competing cations).

Response

A comprehensive study to determine the species living in the riparian zone of Chollas Creek has not been conducted. When and if such information becomes available, it will be reviewed to ensure that the most sensitive and/or endangered and threatened species are being protected by this TMDL.

Hardness data is presented in Appendix A. Hardness ranges from 35 to 3,200 mg/L CaCO₃, with an average of 198 and a median of 91 mg/L CaCO₃. These higher hardness concentrations certainly represent the extreme upper end. However, for all applications of CTR formulas, hardness will be capped at 400 mg/L CaCO₃. As additional toxicity information becomes available, the protective ability of this TMDL at extreme low and high hardness concentrations will be reviewed. We hope that this additional information will include the data necessary to populate the Biotic Ligand Model.

5. Sampling Requirements

Comment

There is insufficient material available regarding the spatial and temporal aspects of the monitoring/sampling plan to comment on its usefulness in assessing Load and Waste Load allocations for the Chollas Creek Watershed. In the absence of designating sampling requirements, it would be appropriate and necessary at a minimum to provide guidance on the development of such a plan in the Technical Report.

Response

The cities of San Diego, Lemon Grove, and La Mesa, the County of San Diego, and the San Diego Unified Port District are conducting a metals monitoring and reporting program under order of the Regional Board (Order No. R9-2004-0227). The order stipulates that all sampling will be conducted using appropriate methods and that analyses will use approved techniques and meet minimum detection levels. Sections 11 and 12 of the draft Technical Report provide further details and sufficient guidance for the responsible parties to develop a revised monitoring and reporting program as part of the TMDL Implementation Plan if required by the Regional Board.

6. Water-effect Ratio

Comment

Water-effect ratios provide a way to calibrate numerical targets to site-specific conditions. These include endogenous species and/or water quality parameters that may vary from those used to develop the standard in sensitivity and influence on toxicity, respectively. These are typically derived after extensive on-site testing and are usually initiated by regulated parties. This approach (i.e., making unity the WER default and letting the regulated community establish site-specific conditions under the guidance of the Regional Board) is reasonable, especially given that WER are often implemented to make conservative Numerical Targets less restrictive. As discussed above for numerical targets, acute criteria are influenced less by site-specific conditions (i.e., WER close to unity; Cherry et al., 2002). Cherry et al. (2002) established a site specific CMC for copper in the Clinch River, VA. This required a battery of toxicity tests conducted using 17 genera native to or currently residing in the river that were not part of the derivation of the Final Acute Value (FAV) used in

the current U.S. EPA regulations. They concluded that the site specific CMC was not substantially different than the national copper criteria. They suggested site-specific adjustments would be most meaningful for criteria developed to protect against chronic exposures and low-level impact. I could find no published reports detailing successful integration of site-specific numerical targets using a WER approach.

It should be noted that one additional source of site-specific variability could easily be incorporated into the TMDL. Direct measurements of dissolved metals can be influenced by a number of parameters and the use of conversion factors to translate total metal concentrations into dissolved is somewhat arbitrary and likely not reflective of the specific chemistries found within the watershed. It would seem reasonable to require that the monitoring plan require dissolved metals to be measured.

Response

The Regional Board appreciates Dr. Shaw's insights on the application of the water-effect ratio (WER) to freshwater systems. If and when a WER study is undertaken for Chollas Creek, the Regional Board will ensure that any site specific chronic conditions are protective of the beneficial uses of the creek. The monitoring plan of Sections 11 and 12 of this report does require the sampling and analysis of dissolved metals. Furthermore, under the ongoing sampling plan, total metals are also being sampled.

7. Source Analysis

Comment

The methods or literature used to determine that the majority of run-off entering Chollas Creek is via the storm water conveyance system (MS4s, Section 4, introduction, p. 15) are not clearly stated. It makes sense given that there are no other point sources, but the reader is left to make the assumption that direct run-off into the creek is negligible (i.e., both volume and source). This is a crucial point as it identifies/acknowledges the jurisdiction of NPDES WDR and I think a citation or further explanation of this determination is warranted, especially since it places the load responsibility on 20 sources identified through NPDES permit requirements (Section 4.1, pp. 15-16). It would seem a mass accounting of volume entering via storm water conveyances and exiting the creek was used, but this was not mentioned. This conclusion also makes sense empirically because a direct link between storm water discharges and creek toxicity has already been established (Schiff, 2001). Given that storm water is the major source of load input for Chollas Creek, the paradigm of identifying sources and modeling land-use specific loads for MS4s is reasonable. Additional comments on load estimates and source identification are given below (Questions 7-10).

Response

The end of the first paragraph of Section 5.1 has been modified to clarify any confusion over the source of water and over the persons responsible for the water in the creek. The following text has been added:

The small size of the creek's riparian zone and the encroachment of development along the creek make the amount of run-off directly to the creek much smaller than that entering from storm drains. Furthermore, under the current MS4 WDRs, the creek itself is considered part of the storm drain system. Therefore, parties named in the Order are responsible for not only the run-off entering the creek, but also for the water in the creek itself.

8. Land Use Model**Comment**

As a non-modeler I found the model description in Appendix D accessible. It did a great job explaining the process of data acquisition, populating model parameters, calibration, and independent validation, which are critical for model development. It also was effective in conveying the strengths, weaknesses, and limitations of the models, especially with regards to data gaps/needs and appropriate/inappropriate applications.

Response

Comment noted.

9. Model Interpretation

The immediate deficiencies are obvious; lack of input data (especially water quality measurements during dry weather conditions). Given these limitations it is difficult to assess the models performance. While it has potential to estimate metal concentrations in the Creek or support load allocations across varying condition, these identified deficiencies limited its application to identifying potential sources to target for load reductions. While this is useful it has less direct bearing on the derivation of the TMDL. As noted in Section 4, when data are sufficient they could be readily incorporated into the model.

Response

Comment noted.

10. Source Analysis Literature**Comment**

The application of results from other studies to Chollas Creek is no different than most any discussion section found in a peer-reviewed article where the objective is to discuss results (strengths and weaknesses) in context of the body of existing literature. In this sense, such an approach seems not only warranted, but also

mandated. I found the literature selections for comparisons justified in terms of similarities (i.e., the most similar studies were selected). Similarities included geographical proximity, population size, land-use, policy, etc. However, in all cases differences and their potential to influence interpretations were highlighted. The only reference I question is the inclusion of Brown and Caldwell, (1984), which was used in section 4.4.2, p. 31. While its limits were clearly noted, the inclusion of lead loading data prior to the CAA ban of lead and lead additives in gasoline provides little area for comparison.

Response

The inclusion of deposition rates from Fresno, California in 1984 in the Source Analysis of this TMDL illustrate the upper range of possible lead atmospheric deposition. The Clean Air Act has drastically reduced the amount of lead that can reach the atmosphere. Nevertheless, the depositional rate from Fresno remains in the technical report as an informational item. When and if a local atmospheric deposition study is conducted, a comparison of the lead rates with those estimated from the 1984 study will be interesting. Only then will evidence be available to test the reasonable assumption that a watershed of cars with unleaded fuel will lead to a lower rate of atmospheric lead deposition than that observed in Fresno in 1984.

11. Data Deficiencies

Comment

The largest data gap I have found for the entire document deals with the lack of information pertaining to a monitoring plan. This is critical to fulfill one of the necessary requirements of Linkage Analysis (i.e., providing the quantitative link between the TMDL and attainment of WQs) and does not seem to be appropriately identified (SEE RESPONSE TO QUESTION 4). Another unidentified gap appears in Section 5 (Linkage Analysis, p. 39), which states that the technical report is required to “estimate the total assimilative capacity (loading capacity) of Chollas Creek for the metals and describe the relationship between Numeric Targets and identified metal sources.” I found no description of the later in this section. Also, as stated above it is a little unclear the role the model is serving (i.e., how it will be applied) in the TMDL development. Perhaps, I’m missing something, but it seems a little anticlimactic after reading section 4 and Appendix D that describe the model to get to the Linkage Analysis Section only to discover it has little application to TMDL development.

Response

The details of the monitoring plan can be found in sections 11 and 12 of the of this report. Please see the response to comment no. 5 above for more information regarding the monitoring requirements of this TMDL.

The Regional Board agrees that the relationship between Numeric Targets and identified metal sources is not clearly explained in the Linkage Analysis Section. Therefore, the following text has been added as the new third paragraph of Section 6:

These loading capacities, which are equal to the Numeric Targets, will apply to the entirety of Chollas Creek and during all times of the year. Each of the land uses identified in the Source Analysis portion of this TMDL will not be allowed to have runoff or in-stream waters in excess of these concentrations. Furthermore, all other sources of copper, lead and zinc to Chollas Creek will be expected to not cause the creek to exceed these loading capacities. Once these capacities are achieved, it is expected that Chollas Creek copper, lead and zinc concentrations will be protective of the creek's beneficial uses.

The model described in section 5 and in Appendix D was used to identify and quantify the relative sources of copper, lead and zinc to Chollas Creek for the Source Analysis. Once the data deficiencies are overcome, the model will be used to more accurately quantify the mass loads of these metals from the creek to San Diego Bay. At that point, the TMDLs for copper, lead and zinc in Chollas Creek will be revised to contain both a concentration limit applicable at all times and a mass load limit that is not to be exceeded on an annual basis. This model refinement is expected to take place as part of the development of the TMDLs for the Mouths of Chollas and Paleta Creek in San Diego Bay.

12. Synergistic Toxicity

Comment

There is evidence for synergistic (i.e., greater than additive) and additive (which could also produce scenarios described above) effects of binary mixtures of copper and zinc and lead and zinc (Kraak et al., 1993; Franklin et al., 2002; Utgikar et al., 2004). However, published reports include laboratory studies that have focused on lower trophic levels (i.e., bacteria, phytoplankton, zooplankton). None of these studies investigated concentration ranges applicable to chronic effects and for the most part they focused on binary rather than more complex mixtures. It should be noted that mixture toxicity can be difficult to assess even in the laboratory as results (i.e., antagonism, additive effects, synergism) can vary with species, strain, concentration, and other parameters (Franklin et al., 2002, Borgmann et al., 2003, and numerous others). For example, Martinez et al. (2004) in studies with Chironomus tentans found lead and zinc to interact antagonistically to produce sub-chronic/population level effects (i.e., mouth part deformities), which is opposite from the studies cited above. This question could be pertinent, but does not appear to have been addressed in the de-listing of cadmium. There are numerous studies detailing interactive effects of cadmium combined with zinc, lead, and copper. Again, observed effects range from synergism to antagonism, but evidence exists for the scenario raised above where metals are present below the CTR concentrations and interact in a synergistic (or depending on concentration in an additive) manner to produce toxicity (Beisenger et al., 1986; Kraak et al., 1993; Jak et al., 1996; Barata et al., 2002; Franklin et al., 2002). The CTR Numerical Targets are derived for individual chemicals and do not account for mixtures. However, given the variability in the nature of interactions reported for these metals, interactions would be difficult to regulate in the absence of site-specific data. In summary, I would conclude that while some evidence for metal

interactions exists, appropriate determinations of effects would need to include site-specific variables in order to be scientifically defensible. The BLM if/when it is adopted could eventually provide a means of dealing with metal mixtures (Paquin et al., 2002; Niyogi and Wood, 2004; Playle, 2004).

Response

The Regional Board agrees that synergistic effects among metals that are individually below CTR may produce toxicity and that these interactions would be difficult to regulate in the absence of site-specific data. Should this site-specific data become available at some future date, it could be incorporated into the TMDL.

Chollas Creek samples collected and analyzed between February 2000 and February 2004 indicated no (0 percent) exceedances of the CTR for dissolved cadmium. Applying the listing policy (SWRCB, 2004) to the available cadmium data confirms that cadmium should be delisted. Therefore the Regional Board is recommending that cadmium in Chollas Creek be removed from the Clean Water Act List of Water Quality Limited Segments. The Regional Board would reconsider the listing should data become available indicating that cadmium concentrations have increased above the CTR, or that cadmium in a synergistic interaction, is producing toxicity.

13. Linkage Analysis

Comment

The Waste Load and Load allocations are directly linked to Water Quality Standards defined by the numerical limits, as they are identical. The decision was made by the Board to take a conservative (i.e., from the protection standpoint) approach and set load allocations based on concentration rather than mass. In other words, it is not the relative amounts (i.e., mass) of metals, but rather their respective concentrations that determine load and load reductions will be based on maintaining concentrations of metals at or below these concentration based targets (the exact concentration is fluid and depends on the water hardness). This approach seems reasonable given the dynamic nature of the system. There is one peer-reviewed study and at least one technical report that link effects of storm water drainage and more specifically the metal component of this drainage to toxicity in aquatic-life in Chollas Creek and the portions of San Diego Bay it enters (Schiff et al, 2001; 2003). Since the load allocations are identical to the numerical limits my response to question 3 is also applicable here.

Response

Comment noted. Please see the response to comment no. 4 for a discussion of the Numeric Targets.

14. Margin of Safety

Comment

The explicit 10% MOS incorporated into the TMDL represents a commonly employed safety factor. The 10% load correction is to guard against the uncertainty inherent in the Source Analysis and Linkage Analysis; differences between total and converted dissolved metal concentrations; and site-specific differences in CTR derived Numerical Targets. It is difficult to comment on the appropriateness (or scientific validity) of the 10% correction. There was greater than 10% variability in measured metal concentrations (Table 2.1). Some explanation for the rationale behind the 10% MOS would be helpful. In addition, there are implicit MOS that stem from using measured rather than estimated hardness values to calculate the TMDL. Likewise, as discussed below, the CTR values incorporate 50% correction.

I didn't understand the argument provided in the last paragraph of section 6 (p. 41). Metal interactions were discussed in question 11 above. There are numerous explanations for interactive effects, which have been observed for copper, lead, and zinc. For example, common uptake routes (e.g., calcium channels for cadmium and zinc) or distributions and detoxications could account for interactive effects. While speciation affects toxicity, biological processes have also been shown to influence interactions during laboratory tests conducted under identical water chemistries. Perhaps chemical interactions refers to complexation with anions and negatively charged sites on particulates, which would reduce bioavailability. Anyway, this paragraph/point could use clarification.

Response

The explicit 10 percent Margin of Safety (MOS) was incorporated into the TMDL to account for any uncertainties in the analysis of metals. Therefore, an explicit MOS is warranted. The choice of ten percent is not based on the amount of error in the data, nor on any scientific study that establishes that the CTR formulas may have a 10 percent error. Rather, the 10 percent MOS is based upon the size of the MOS found in other similar TMDLs. Please see the TMDL for Selenium in the Lower San Joaquin River in Region 5, the Clear Lake TMDL for Mercury in Region 5 and the TMDL for Toxic Pollutants in San Diego Creek and Newport Bay, California by the USEPA.

The Regional Board agrees that the last paragraph of section 7 needed clarification. The entire paragraph has been changed to the following:

Another implicit MOS was not allowing for metal interactions with anions and negatively charged sites on particulates when calculating the loading capacity and allocations. Theoretically, an increase in bioavailability from these types of chemical interactions in water would only take place in waters with low pH levels. The increased aqueous acidity (low pH levels) would yield higher levels of free metal ions and thereby increase bioavailability to aquatic organisms. Such low pH levels in ambient waters are more likely to be observed in areas of high acid rain; these low pH conditions are not likely in San Diego. Therefore, metal interactions with negatively charged anions and particles

within the water were assumed to only decrease bioavailability. Not allowing for this interaction makes the TMDL concentration more conservative.

15. California Toxics Rule Inherent Margin of Safety

Comment

As stated above, the one peer-reviewed manuscript that described formulating site-specific CMC for copper concluded that including over 17 sensitive site-specific species to calculate the FAV did not significantly lower the CMC (Cherry et al., 2002). Also, the CTR are based on national ambient water quality criteria, for which the science has been validated through several updates over 20 years. It wasn't until recently that new approaches (i.e., BLM) gained favor. Given the defensibility and robustness of this approach coupled with the lack of evidence for extreme site-specific sensitivities another 10% MOS does not seem warranted.

Response

The explicit 10 percent Margin of Safety (MOS) was incorporated into the TMDL to account for any uncertainties in the analysis of metals. The CTR formulas provide conservative water quality criteria that are protective of aquatic life. However, since the equations are based upon available laboratory data, they may not be protective of all aquatic life in Chollas Creek. Therefore, the Regional Board believes that an explicit MOS is warranted.

16. Critical Conditions

Comment

The use of a concentration (mass/volume) based TMDL negates effects of variable flow on load allocations, since regardless of the amount (mass) of metals that are present, it is the CTR derived concentrations that must be maintained. Concentration based criteria have a long history of use and even the newly proposed BLM, which relate an amount of metal bound to a critical biotic ligand to toxicity, are still expressed as concentrations. The use of concentrations is an appropriate approach for Chollas Creek given the limited data available for Land Use Models and other methods used to estimate the metal load entering during wet and dry periods. Likewise, the use of CMC and CCC targets ensure critical exposure conditions (acute, chronic) are incorporated. Furthermore, the inclusion of measured rather than estimated hardness concentrations reduce seasonal variability, especially during critical conditions. Provisions are also made to revisit other stream chemistry parameters that were not included in this TMDL if/when the BLM for copper is adopted. Collectively, these measures stabilize the TMDL even over extreme/critical conditions that could be occurred within the basin.

Response

Comment noted.

17. Monitoring Details

Comment

With regards to additional scientific issues relating to the Technical Report, there was little mention of specific methods, especially for metal sampling and analysis. Most every question in this reviews asked the reviewer to comment on the scientific methods, so it would appear to be information useful this review. Inclusion of methods could be done in the form of references, but I think their inclusion is necessary to ensure appropriate sampling/measurement techniques are employed and thus, TMDLs are meaningful.

Response

The details of the monitoring plan can be found in sections 11 and 12 of this report. Please see the response to comment no. 5 above for more information regarding the monitoring requirements of this TMDL.

18. Specific comments regarding the Technical report are as follows

Comment A

Attachment 1, p. 1, second paragraph- There are more appropriate references than More and Ramamoorthy, 1984).

Response

Please see the response to comment no. 2 above for a discussion on biomagnification and for the changes made to this TMDL Report.

Comment B

Technical Analysis, p.1, 1st paragraph, 1st sentence- insert 'and a' between County and tributary.

Response

This correction has been made.

Comment C

“ “, p. 1, 1st paragraph, with regards to de-listing Cd, see question regarding synergistic effects above.

Response

The Regional Board still believes that Cd should be removed from the Clean Water Act List of Water Quality Limited Segments. Please see the response to comment no. 12 for a more in-depth discussion.

Comment D

Problem statement, p. 2, in the 1st paragraph inconsistencies with the use of lower and lowest.

Response

Paragraph has been updated to use 'lowest' in both instances.

Comment E

“ “, same paragraph- Ceriodaphnia is misspelled.

Response

This correction has been made.

Comment F

“ “, same paragraph- not exactly clear on the use of the sea urchin. I assume this is from test of Bay water? Also, in general toxicity data were not presented in clearly.

Response

The sea urchin test was run to see if Chollas Creek stormwater could be negatively impacting San Diego Bay. To avoid any confusion over the details of the Toxicity Identification Evaluation (TIE), the last sentence of the first paragraph of section 3 has been deleted. The full citation for the TIE study can be found in the reference section.

Comment G

Section 2.3, p. 8, 2nd paragraph, last sentence; it states that compliance shall be evaluated using a 96-hr acute bioassay. The Daphnia tests mentioned are 48-h tests.

Response

The italicized text in section 3.3 is taken verbatim from the Basin Plan. Therefore, we do not want to change this quotation as it appears in this TMDL Report. However, this correction will be considered during the drafting of the monitoring plan and during the next revision of the Basin Plan.

Comment H

Section 2.4., p. 8, 1st paragraph, poor reference for biomagnification of metals.

Response

The following reference has been added to that section:

Besser, J. M., W.G. Brumbaugh, T.W. May, S.E. Church and B.A. Kimball,
Bioavailability of metals in stream food webs and hazards to brook trout

(*Salvelinus fontinalis*) in the Upper Animas River Watershed, Colorado. *Arch Environ Contam Toxicol* **40** (2001), pp. 48–59.

Please see the response to the Comment A for further discussion.

Comment I

“ “, *toxins are natural compounds (i.e., snake venom, ammonia); toxicants is the appropriate word here.*

Response

This change has been made.

Comment J

“ “. *Next sentence; ...same locations more commonly found at higher concentrations in*

Response

This change has been made.

Comment K

“ “. *P. 9, Better references than Buffle, 1989.*

Response

The Regional Board appreciates the additional support for concepts put forth in section 3.4 and will be working to track down these references.

Comment L

“ “. *P. 9, 2nd paragraph, last sentence, Unclear what is being referred to where the implementation plan is located?*

Response

A reference to sections 11 and 12 has been added to this paragraph.

Comment M

Section 2.6, p. 10. In reference to the monitoring site, it is stated that this sampling station is representative of the entire watershed. How was this determination made?

Response

This determination was based upon the similarities in land use between the watersheds of the two forks of Chollas Creek. The last sentence of the first paragraph of section 3.6 has been changed to:

This station samples run-off that is representative of the entire watershed because the land use distribution in the north fork portion of the watershed is nearly identical to the land use distribution of the entire watershed as shown in Table 3.5 below.

Comment N

“ “, next paragraph. Replace 1994.95 with 1994-95.

Response

This change has been made.

Comment O

“ “. Same paragraph. Provide methods for toxicity tests.

Response

The methods for these toxicity tests can be found in the original Stormwater Reports for the various years. These documents can be viewed at the Regional Board office.

Comment P

“ “. Same paragraph. Sentence that states, “Reproduction of the water fleas was generally not impaired, even in individuals that died later in the test.” Is not clear.

Response

The part that reads “even in individuals that died later in the test” has been removed from the text. The Stormwater Reports containing these toxicity test results can be reviewed at the Regional Board office.

Comment Q

Section 3, Numeric Targets, 1st paragraph. Reference the EPAs Metal Translator or whatever the source of the conversion factors was.

Response

References for the conversion factors are properly cited in section 4.3, where they are discussed in detail.

Comment R

“ “. Same page, last paragraph, States that the targets given in table 3.1 were derived to be protective of marine aquatic life from toxicity. Should it read ‘freshwater’ aquatic life?

Response

This change has been made.

Comment S

“ “ p. 12, Equation 3.2; Where: make sure subscripts agree with acute target. I think they should be A instead of C. This also needs correcting in the descriptive sentence to follow.

Response

This change has been made.

Comment T

Section 3.2, Water Effects Ratios. 1st paragraph, 1st sentence, delete more

Response

This change has been made.

Comment U

“ “. Last sentence. I would remove reference to the appendix if it will not be included.

Response

The reference has been maintained and the appendix will be included as part of the TMDL report.

Comment V

Section 3.6. last sentence. Replace biochemical with biotic. (the gill is not a biochemical site)

Response

This change has been made.

Comment W

Section 4.2.1.1. add period between next to last and last sentence.

Response

This change has been made.

Comment X

Section 4.3. p. 28. 2nd paragraph. Replace Creeks with Creek

Response

This change has been made.

Comment Y

Section 4.3.2. p. 31. 1st paragraph. I don't think the argument is strengthened with the inclusion of the 1984 lead reference (SEE Comments above.).

Response

Please see response to comment no. 10 above.

Comment Z

Section 4.4.3. p. 31. second sentence. Replace do with low.

Response

This change has been made.

Comment AA

In addition, there are a number of mis-labelings in the appendices.

Response

These corrections have been made.

19. Additional references provided by Dr. Shaw.

Barata, C., Markich, S.J., Baird, D.J., Taylor, G. and Soares, A.M.V.M., 2002. Genetic variability in sublethal tolerance to mixtures of cadmium and zinc in clones of *Daphnia magna* Straus. *Aquat. Toxicol.* 60, pp. 85–99.

K.F. Biesinger, G.M. Christensen, J.T. Fiandt. Effects of metal salt mixtures on *Daphnia magna* reproduction. *Ecotoxicol Environ Saf*, 11 (1986), pp. 9-14.

J.M. Besser, W.G. Brumbaugh, T.W. May, S.E. Church and B.A. Kimball, Bioavailability of metals in stream food webs and hazards to brook trout (*Salvelinus fontinalis*) in the Upper Animas River Watershed, Colorado. *Arch Environ Contam Toxicol* 40 (2001), pp. 48–59.

W.P., Borgmann, U., Dixon, D.G. and Wallace, A., 2003. Effects of metal mixtures on aquatic biota: a review of observations and methods. *Human and Ecological Risk Assessment* 9, pp. 795–811.

C.Y. Chen, R.S. Stemberger, B. Klaue, J.D. Blum, P.C. Pickhardt and C.L. Folt, Accumulation of heavy metals in food web components across a gradient of lakes. *Limnol Oceanogr* **45** (2000), pp. 1525–1536.

D.S. Cherry, J.H. Van Hassel, J.L. Farris, D.J. Soucek, R.J. Neves, Site-specific derivation of the acute copper criteria for the Clinch River, Virginia. *Human Ecolog Risk Assess* **8** (2002), pp. 591-601.

N.M. Franklin, J.L. Stauber, R.P. Lim, P. Petocz. Toxicity of metal mixtures to a tropical freshwater alga (*Chlorella* sp): the effect of interactions between copper, cadmium, and zinc on metal cell binding and uptake. *Environ Toxicol Chem.* **21** (2002), pp. 2412-22.

A. Jarvinen and G. Ankley, editors, *Linkage of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals*. (1999), SETAC press, Pensacola, FL. pp. 364.

M.H.S. Kraak, H. Schoon, W.H.M. Peeters and N.M. van Straalen, Chronic ecotoxicity of mixtures of Cu, Zn, and Cd to the zebra mussel *Dreissena polymorpha*. *Ecotoxicol. Environ. Saf.* **25** (1993), pp. 315–327.

D.D. MacDonald, C.G. Ingersoll, T. Berger. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch Environ Contam Toxicol* **39** (2000), pp. 20-31.

Gensemer, R.B. Naddy, W.A. Stubblefield, J.R. Hockett, R. Santore and P. Paquin, Evaluating the role of ion composition on the toxicity of copper to *Ceriodaphnia dubia* in very hard waters, *Comp. Biochem. Physiol.* **133C** (2002), pp. 87–97.

P.R., Gorsuch, J.W., Apte, S., Batley, G., Bowles, K., Campbell, P., Delos, C., DiToro, D., Dwyer, R., Galvez, F., Gensemer, R., Goss, G., Hogstrand, C., Janssen, C., McGeer, J., Naddy, R., Playle, R., Santore, R., Schneider, U., Stubblefield, W., Wood, C.M. and Wu, K., 2002. The biotic ligand model: a historical overview. *Comp. Biochem. Physiol.* **133C**, pp. 3–35.

R.G. Jak, J.L. Maas, M.C.Th. Scholten, Evaluation of laboratory derived toxic effect concentrations of a mixture of metals by testing fresh water plankton communities in exposures, *Water Res* **30** (1996), pp. 1215–1227.

E.A. Martinex, B.C. Moore, J. Schaumlöffel, N. Dasgupta. Effects of exposure to a combination of zinc- and lead-spiked sediments on mouthpart development and growth in *Chironomus tentans*, *Environ Toxicol Chem*, **23** (2004) pp. 662-667.

S. Niyogi, C.M. Wood, Biotic ligand model, a flexible tool for developing site-specific water quality guidelines for metals, *Environ Sci Technol*, **38**(2004), pp. 6177-6192.

R.C. Playle, Using multiple metal-gill binding models and the toxic unit concept to help reconcile multiple-metal toxicity results. *Aquat Toxicol*, **67**(2004), 359-370.

M. R. Quinn, X. Feng, C.L. Folt and C.P. Chamberlain, Analyzing trophic transfer of metals in stream food webs using nitrogen isotopes, *The Science of The Total Environment* **317** (2003), pp. 73–89

K. Schiff, S. Bay, D. Diehl, Storm water Toxicity in Chollas Creek and San Diego Bay, California, *Environ Monit Assess*, **81** (2003), pp. 119-32.

B.C. Suedel, J.A. Boraczek, R.K. Peddicord, P.A. Clifford and T.M. Dillon, Trophic transfer and biomagnification potential of contaminants in aquatic ecosystems. *Rev Environ Contam Toxicol* **136** (1994), pp. 21–89.

Timmermans, K. R., van Hattum, B., Kraak, M. H. S. & Davids, C. Trace metals in a littoral foodweb: Concentrations in organisms, sediment and water. *Sci. of the Total Environ* **87-88** (1989), pp. 477-494.

V.P. Utgikar, N. Chaudhary, A. Koeniger, H. Tabah, J.R. Haines, R. Govind. Toxicity of metals and metal mixtures: analysis of concentration and time dependence for zinc and copper, *Water Res* **38** (2004), pp. 3651-8.

Response

The Regional Board appreciates these additional supporting references and will consider them as the need arises.

Response to Peer Review Comments from Dr. Garrison Sposito and Ms. Jasquelin Peña

20. Overall Summary

Comment

The draft report under review provides technical information related to the establishment of Total Maximum Daily Loads (TMDLs) for Chollas Creek, an intermittent stream that drains a highly urbanized watershed through two major tributaries in the San Diego area. Outflow from the creek, whose lower reach (see photo of the North Fork, below, taken by J. Peña, March 2005) has impaired water quality, is into San Diego Bay.

Response

Comment noted.

21. National Toxics Rule vs California Toxics Rule

Comment

Note, however, that the introductory statements on page 4 of the draft report appear to be contradictory in respect to the documentation of impaired water quality, implying that National Toxics Rule criteria are more often exceeded than California Toxics Rule criteria, while calling the latter “more stringent.”

Response

The Regional Board did not intend to imply that the water quality criteria contained in the CTR are more “stringent” or lower than the values contained in the NTR. Water quality criteria in the CTR are based on dissolved metal concentrations for copper, lead and zinc, unlike water quality criteria in the NTR, which are based on total copper concentrations. Therefore, it is possible to exceed values contained in the NTR but not exceed the water quality criteria in the CTR because they are measuring different aspects of a metal. In order to avoid further confusion, the text on page 4 at the beginning of the second sentence, “While exceeding NTR criteria” was deleted.

22. Definition of TMDL

Comment

The TMDLs discussed in the report are for the metals, copper, lead, and zinc. As noted in the Introduction of the draft report, TMDLs are load allocations (mass per day) of pollutants to a waterbody, considering both point sources and nonpoint sources, such that the assimilative capacity of the waterbody in respect to applicable water quality objectives is not exceeded.

Response

Comment noted. For clarification purposes, in accordance with the applicable federal regulation [40 CFR 130.2(i)]: “TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.” The TMDLs for metals in Chollas Creek are concentration-based.

23. Numeric Targets**Comment**

The methodology followed in the draft report for the three metals of concern is to apply the USEPA- California Toxics Rule (USEPA-CTR) to obtain numeric targets for dissolved metals in Chollas Creek. The dissolved metal concentrations are calculated for both acute (one-hour average) and chronic (four-day average) conditions from USEPA-CTR statistical regression equations that include factors for site-specific toxicity effects, total-to-dissolved metal concentrations, and direct hardness effects (Table 3.1 in the draft report). Hardness data for the waterbody will be required in order to implement these equations.

Response

The Regional Board agrees that hardness data will be necessary to monitor for compliance with the TMDLs. Water quality criteria in the CTR are expressed as a function of hardness. The Regional Board will require the dischargers to collect hardness data in addition to metals concentrations as part of the monitoring required to comply with the TMDLs. Please note that Table 3.1 is now labeled as Table 4.1.

24. Temperature and pH**Comment**

It is possible to include direct effects of temperature and pH in the equations, but this was not done in the draft report.

Response

The equations in the CTR do not include the parameters of temperature or pH. The Regional Board will continue to use the equations defined in the CTR with the WER = 1.00 until it can be demonstrated that an alternative approach is appropriate based on further studies or information.

25. Site-Specific Objectives**Comment**

Site-specific toxicity effects also were not considered [i.e. Water Effects Ratio (WER) = 1.0 in the regression equations] and the total-to-dissolved metal concentrations ratio for each metal was set equal to a fixed constant for all conditions using the default USEPA-CTR values.

Response

The passage of the CTR in 2000 by USEPA established legally applicable numeric water quality objectives for priority toxic pollutants including copper, lead and zinc in California. Water quality criteria in the CTR are based on dissolved metal concentrations. In the absence of site-specific data, a WER equals one and a constant total-to-dissolved metal conversion factor set in the CTR is appropriate for use in the equations that define the CTR water quality criteria.

Until sufficient information is available to justify a change, using a WER equal to one in the CTR and a constant total-to-dissolved metal conversion factor will ensure protection of beneficial uses in Chollas Creek. However, the Regional Board supports the collection of data and information necessary to determine if a modified WER value or some other site-specific criteria is appropriate and/or to establish a site-specific conversion factor for total-to-dissolved metal concentrations. Once data are available to change the WER or total-to-dissolved metal conversion factor, the State has the discretion to interpret the CTR water quality criteria and modify the TMDLs based on site-specific studies and information for Chollas Creek

26. CTR as Numeric Target

Comment

Although the draft report states that the numeric targets set by using the USEPA-CTR equations are a function of hardness, it does not justify why this choice is appropriate for Chollas Creek, other than its legal applicability in California for inland surface waters (draft report, page 11). Reference to CFR 40 Part 131 provides the following guiding commentary on the toxicological significance of hardness-based USEPA-CTR equations:

f. Hardness

Freshwater aquatic life criteria for certain metals are expressed as a function of hardness because hardness and/or water quality characteristics that are usually correlated with hardness can reduce or increase the toxicities of some metals. Hardness is used as a surrogate for a number of water quality characteristics which affect the toxicity of metals in a variety of ways. Increasing hardness has the effect of decreasing the toxicity of metals. Water quality criteria to protect aquatic life may be calculated at different concentrations of hardness, measured in milligrams per liter as calcium carbonate.

Given the importance accorded in the draft report (page 14) to hardness sampling as part of compliance testing, it would be very useful to have more detailed discussion on the relevance of the above paragraph to water quality criteria for the three metals of concern in Chollas Creek.

Response

The Regional Board agrees that a more detailed discussion regarding the role of hardness to the water quality criteria is important. The above text under “f. Hardness” was added to the end of the first paragraph of section 4.4.

27. Site-Specific Toxicity Evaluation**Comment**

Although the choice of WER = 1.0 in the draft report is a conservative one, procedures are available from USEPA for evaluating site-specific toxicity effects and modifying the Water Effects Ratio accordingly. This additional information may be of special value in respect to copper because of its strong tendency to form toxicity-reducing soluble complexes with dissolved organic matter. Similarly, the use of a constant total-to-dissolved metal concentrations ratio as given by USEPA is problematic, since the chemical forms of copper, lead, and zinc are likely to vary both spatially and temporally depending on streamflow variation and the changing composition of streamwaters, including suspended load. In the draft report, the assumption is made that the USEPA-CTR default values for the three metals are upper limits of the actual values in Chollas Creek, the implication being that actual total-to-dissolved metal concentrations are always larger than the default values used in the USEPA-CTR regression equations. Since toxicity effect should vary inversely with total-to-dissolved metal concentration, this assumption amounts to an implicit Margin of Safety imposed on the recommended dissolved metal concentrations. An alternative approach would be to evaluate total-to-dissolved metal concentrations as a function of turbidity and include turbidity sampling as a part of compliance testing.

Response

Implicit MOS are an allowable component of the TMDL process. TMDL design allows for limitless methodological and equation refinements that find their reasonable limit via best professional judgement. In this instance, the Regional Board will continue with the "WER = 1.0" approach until it can be demonstrated that an alternative approach significantly alters the final result

In addition, please see the response to comment no. 25 above.

28. Hydrologic Modeling**Comment**

In the usual development of TMDLs for a waterbody, hydrologic data and pollutant source analyses are combined with the numeric targets to calculate waste load and load allocations. However, in the draft report under review, although spatial hydrologic modeling and a very thorough metal source analysis are presented, they are used only to determine TMDL Critical Conditions (Appendix D, Section 2.2).

Response

The model described in section 5 and in Appendix D was used to identify and quantify the relative sources of copper, lead and zinc to Chollas Creek for the Source

Analysis. Once the data deficiencies are overcome, the model will be used to more accurately quantify the mass loads of these metals from the creek to San Diego Bay. At that point, the TMDLs for copper, lead and zinc in Chollas Creek will be revised to contain both a concentration limit applicable at all times and a mass load limit that is not to be exceeded on an annual basis. This model refinement is expected to take place as part of the development of the TMDLs for the Mouths of Chollas and Paleta Creek in San Diego Bay.

29. Monitoring Needed

Comment

It appears that most of the data used to develop the TMDLs was collected during stormflows. Additional monitoring during low flow should be implemented since pools of slow-moving or standing water (see photo of Chollas Creek, below, taken by J. Peña) will have very different dynamics—and metal sources—from those associated with high-flow storm events. It is also possible that dissolved metal concentrations during low flow are greater than in the wet season because metal inputs are not diluted by large volumes of rainwater. Also, standing water can undergo evaporation, leading to the concentration of metals in sediments.

Response

The Regional Board agrees that additional monitoring should be conducted during low flow periods to more accurately characterize metals loading to Chollas Creek. The Regional Board will require the dischargers to monitor during dry weather metals concentrations to comply with the TMDLs. Information gathered as a result of this monitoring will be incorporated into the TMDLs as appropriate.

30. Editorial Clarification

Comment

Page 32, Section 4.4.5. In the last sentence, the reader should be reminded that this summary applies strictly to the Santa Clara Valley study.

Response

The draft Technical Report has been updated to reflect this change.

31. Treatment Plant Effluent

Comment

Page 33, Section 4.4.5.2. Quantify the difference between the “back of the envelope calculation” given here and the model results.

Response

As stated in the text, the quantities associated with the treatment plants have been determined to be insignificant because the treatment plants’ effluents have little detectable copper, lead and zinc. Therefore no further analysis is necessary.

32. Pesticide Copper Concentrations

Comment

Page 37, Section 4.5.4. The percentage of copper contained in each pesticide should be included in Table 4.10.

Response

Comment noted. As stated in the text, only a percentage of the pesticide amount shown in Table 5.10 is actually copper or zinc and there is not enough information to quantify the actual amount of copper or zinc that would reach a water body in San Diego County.

33. Load and Waste Load Allcoations

Comment

Because waste load and load allocations were not made, the linkage analysis in the draft report (page 39) consists of identification of the most important metal sources and streamflows to be considered when sampling metal concentration and hardness for assessing compliance with the recommended dissolved metal concentrations. The final recommendations for the three metals are dissolved concentrations equal to 90 % of the dissolved concentrations (i.e. 10 % Margin of Safety) calculated using the USEPA-CTR hardness-based regression equations. These recommended concentrations are compared illustratively to measured concentrations in Appendix G of the draft report. The results in this appendix indicate that maximum observed concentrations of the three metals are significantly greater than the concentrations required to meet water quality objectives, with the discrepancies being much larger at lower hardness values.

Response

Comment noted. For clarification, waste load and load allocations were made in the draft Technical Report. These allocations are concentration-based, in accordance with federal regulations [40 CFR 130.2(i)], which state: "TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure."

34. Biomagnification

Comment

The use of dissolved metal concentrations as numeric targets presupposes that the metals do not increase in concentration at higher trophic levels (i.e. no biomagnification) and that they do not accumulate in sediments. Biomagnification of copper, lead, and zinc in test organisms (e.g. daphnia) has not been observed in laboratory studies, insofar as the reviewers are aware, nor is it expected. Biomagnification is associated with hydrophobic pollutants and hydrophobic chemical forms of pollutants (e.g. methyl mercury), whereas most toxic metals have hydrophilic chemical forms in aquatic ecosystems. It is possible that lead could take

on a hydrophobic chemical form under anaerobic conditions because it can be methylated by microorganisms, but this is very unlikely in well-aerated waterbodies. Accumulation in freshwater sediments is well established for the three metals of concern, which have strong sorption affinities for natural particles, especially those with organic matter content. The case is made in the draft report that metal concentrations in the creek sediments are typically below levels of probable toxic effect and that particle-bound metals are flushed from the creek within one year by winter flows. These conjectures are not unreasonable, but no database currently exists with which to evaluate them, bringing to mind the important possibility that particle-bound metals transported to San Diego Bay may pose a potential toxicity threat, thus making Chollas Creek a source of this threat.

Response

The existing data on sediment metals concentrations in Chollas Creek demonstrated that metals in the sediment are most likely not accumulating in Chollas Creek. Instead, metals adsorbed to particles in Chollas Creek are likely flushed out of the creek during wet weather events, acting as a source of metals loading to the mouth of Chollas Creek and San Diego Bay. A TMDL is currently under development for the mouth of Chollas Creek that will address this issue.

35. Concentration-based TMDL

Comment

Dissolved concentrations of copper, lead, and zinc for acute and chronic conditions calculated from USEPA-CTR regression equations dependent on water hardness are promulgated with a 10 % Margin of Safety instead of TMDLs, which typically combine allowable dissolved metal concentrations with hydrologic and metal source analyses to prescribe mass loadings that meet applicable water quality objectives.

Response

The TMDL is the combination of a total wasteload allocation (WLA) that allocates loadings for point sources, a total load allocation (LA) that allocates loadings for nonpoint sources and background sources and a MOS. For clarification, waste load and load allocations were made in the draft Technical Report. These allocations are concentration-based, in accordance with federal regulations [40 CFR 130.2(i)], which state: “TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.”

36. Scientific Justification for Using CTR

Comment

Detailed scientific justification of the USEPA-CTR hardness-based equations for applicability to Chollas Creek waters in determining allowable metal concentrations is not provided. However, assumptions of no metal biomagnification or accumulation in sediments, which underlie the use of numeric targets based on dissolved concentrations, seem justified.

Response

The CTR hardness-based equations are legally and scientifically applicable to Chollas Creek. The legal applicability is established by federal regulation [40 CFR 131.38] and is sufficient to warrant the use of the CTR for this TMDL. In addition, Chollas Creek is a freshwater system, with variable physical parameters that make the use of the hardness-based equations to prevent toxic conditions scientifically reasonable.

The comment regarding biomagnification is noted.

37. Summary of Current Problem**Comment**

Compliance testing guided by TMDL Critical Conditions will require measurements of both metal concentrations and hardness (as calcium carbonate) for use with USEPA-CTR regression equations that, along with the 10 % Margin of Safety, define the numeric targets. Preliminary calculations indicate that current metal concentrations in Chollas Creek are in excess of these targets, particularly at low hardness values.

Response

The Regional Board agrees with this comment and is requiring hardness (as calcium carbonate) to be measured.

38. Hydrologic Modeling**Comment**

Hydrologic modeling and metal source analyses are used to select TMDL Critical Conditions for compliance testing. Hydrologic modeling is not explicitly used in metal load and waste load allocations. All hydrologic and metal source effects are implicit in these allocations.

Response

Compliance sampling will not be based upon the critical conditions identified in the hydrologic model used in the Source Analysis. Sampling details can be found in sections 11 and 12 of the draft Technical Report.

39. Additional Monitoring**Comment**

The current database for Chollas Creek can be improved by additional monitoring of both metal concentrations during lowflow periods and metal accumulation in creek sediments that may serve as a source of contamination for San Diego Bay.

Response

The Regional Board agrees that additional data should be collected to fully characterize the contribution of metals during dry weather. Monitoring of metals concentrations during dry weather will be required of the dischargers in order to comply with the TMDLs. Further data would also be useful to characterize the contribution of metals in sediment to metals loading into San Diego Bay. The Regional Board will address this issue in a TMDL currently under development for the mouth of Chollas Creek.

40. Additional Toxicity Testing**Comment**

Additional laboratory toxicity testing using Chollas Creek waters would be useful in order to justify the Water Effects Ratio and to evaluate the accuracy of the default total-to-dissolved metal concentration factor assumed in the USEPA-CTR regression equations.

Response

The Regional Board supports the collection of data and information necessary to determine if a modified WER value or some other site-specific criteria is appropriate and/or to establish a site-specific translator for total-to-dissolved metal concentrations. Unfortunately, the Regional Board does not have the resources to actively engage in these investigations. The current WER value of one is appropriate for use in the equations that define the CTR water quality criteria. Until sufficient information is available to justify a change, the value of one is appropriate for all CWA uses, including the SIYB TMDL. In the meantime, using a WER equal to one in the CTR copper objective will ensure protection of beneficial uses in the water column of SIYB. Once data are available to change the WER, the State has the discretion to interpret the CTR copper criteria based on a site-specific WER for Chollas Creek.